THE ENGINEER

DECEMBER 25, 1959 | 28 ESSEX STREET, STRAND, LONDON, W.C.2 | TWO SHILLINGS

LEY'S
'LEMAX'
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MALLEABLE
CASTINGS

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This 'Lemax' casting, for a commercial vehicle planetary two-speed axle, combines the hardened internal gear with part of the differential housing.

The casting, which is 11 inches diameter and weighs 38 lb., meets the following specification:

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Min. elongation in 2": 2%.

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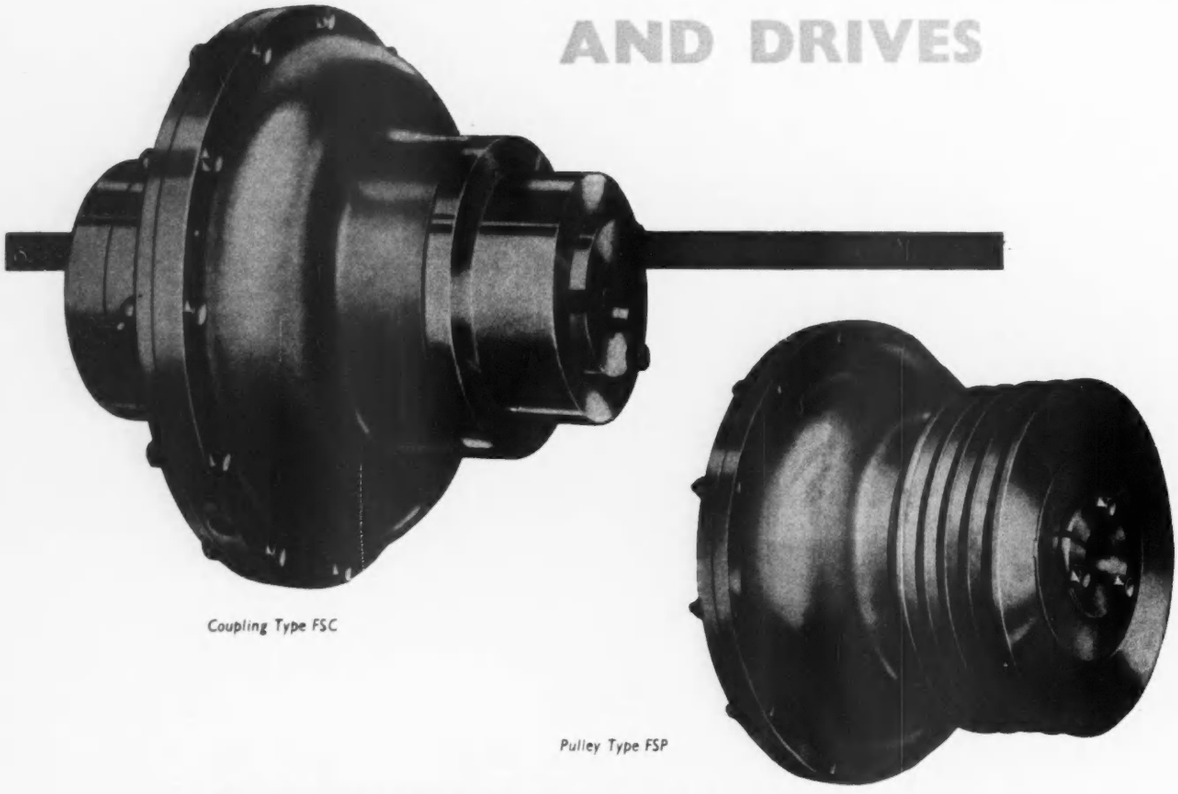

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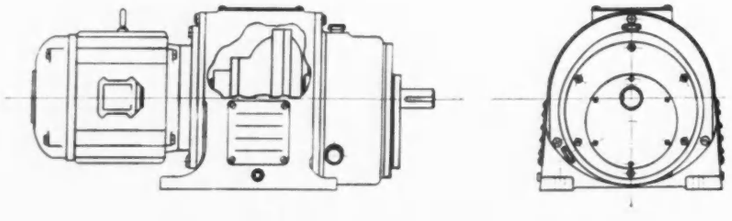

Type FSC Hydraulic Couplings can be supplied in unit form with flange-mounted motor and Universal Ritespeed Reduction Gear as illustrated on left.

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Established 1856

No. 5422 **DECEMBER 25, 1959** VOL. 208

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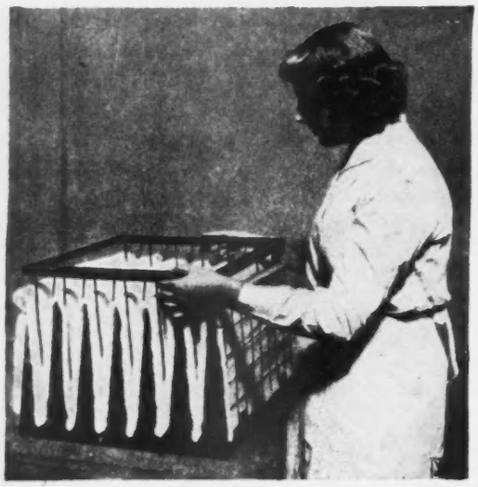

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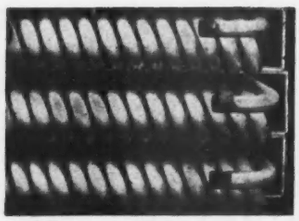

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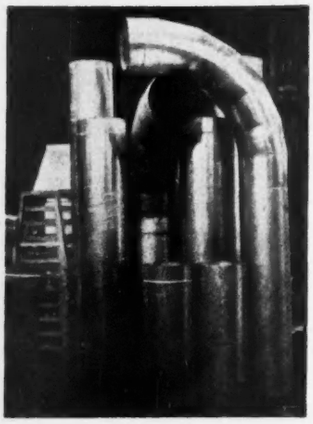

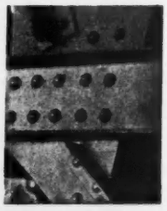

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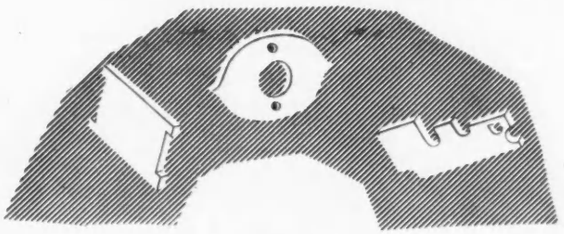

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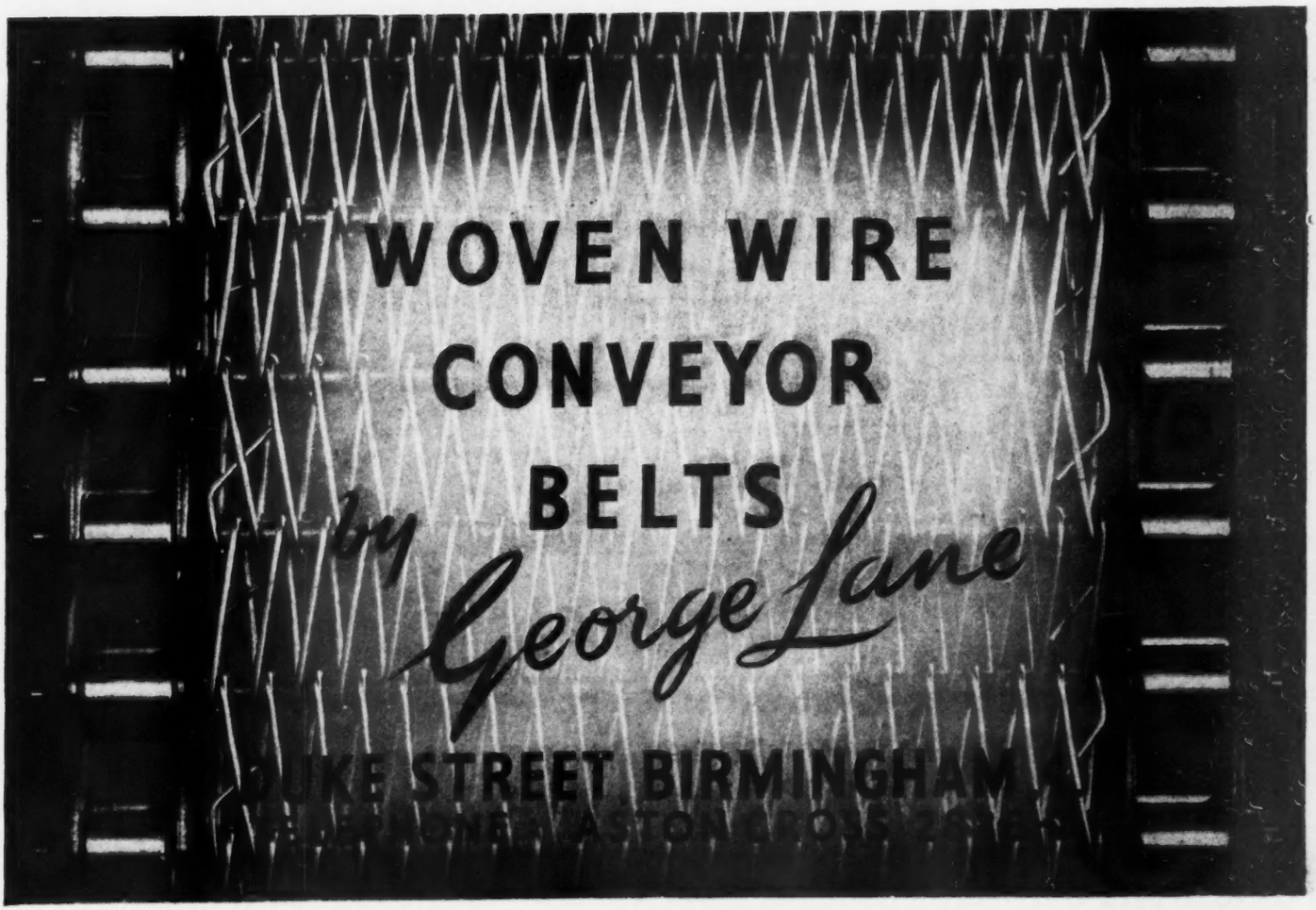

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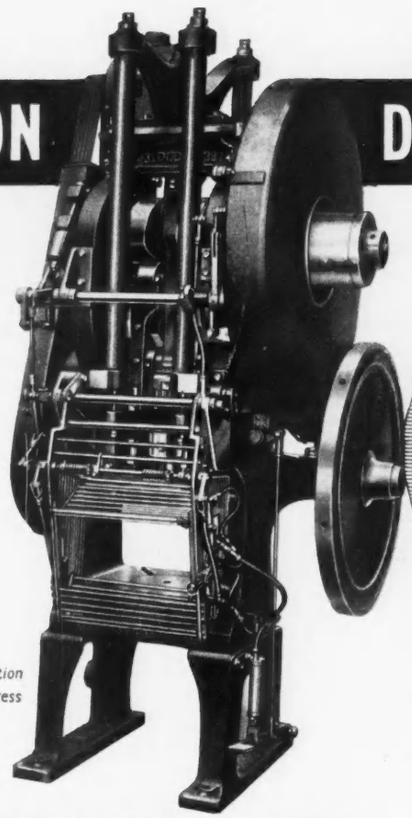

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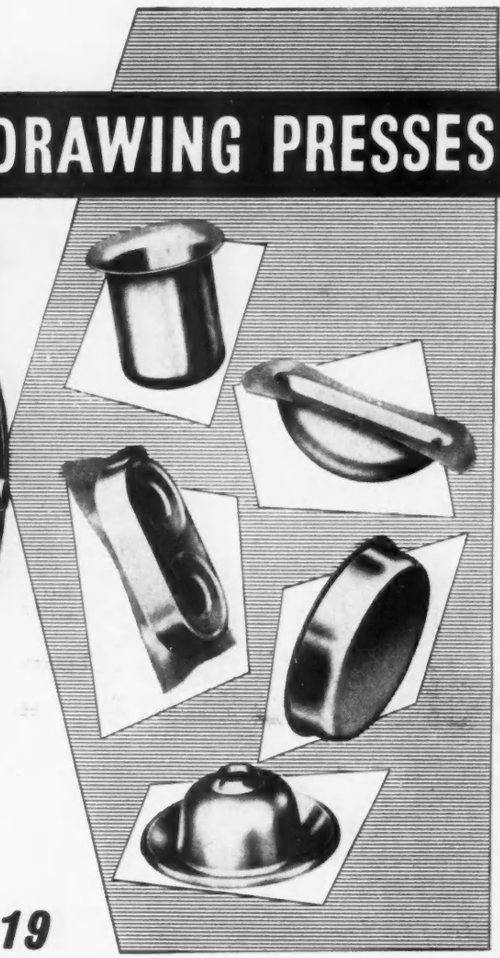

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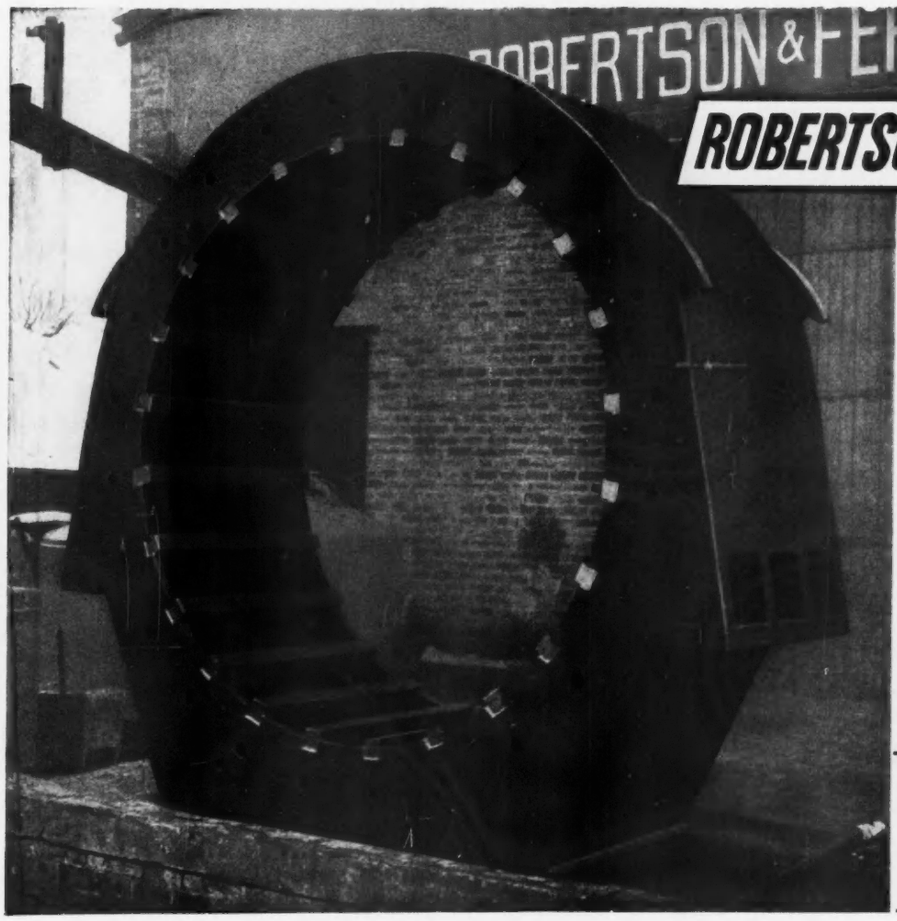

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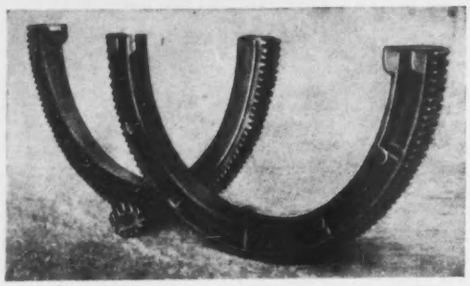

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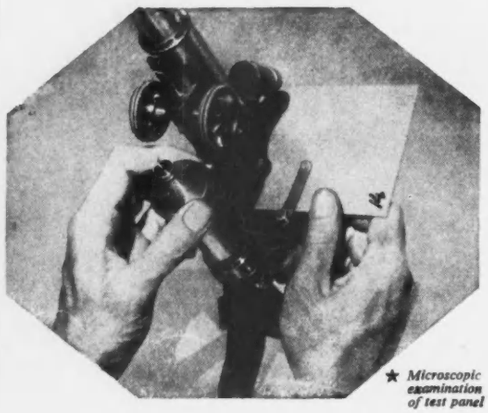

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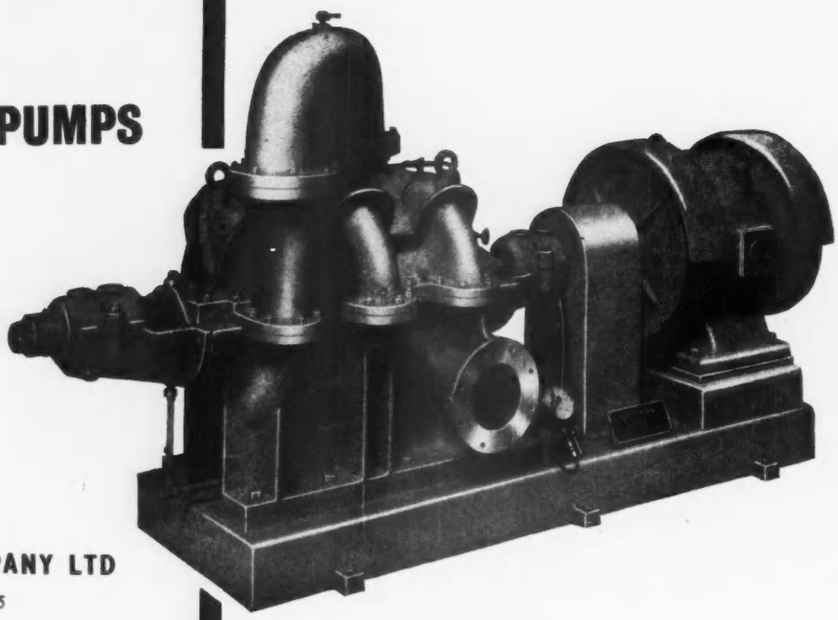

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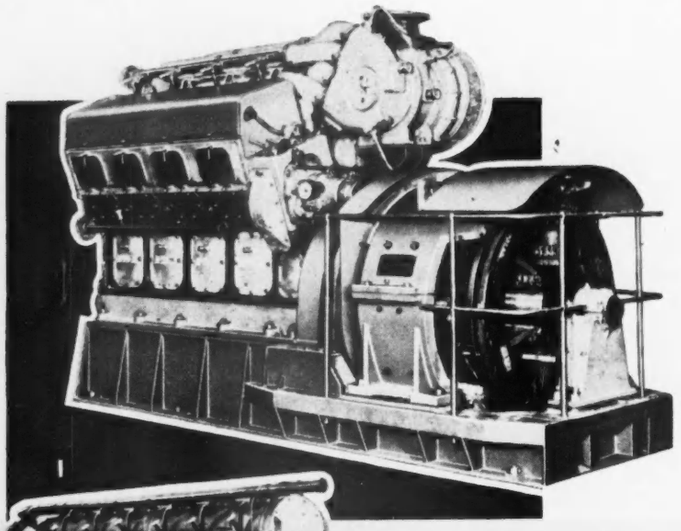

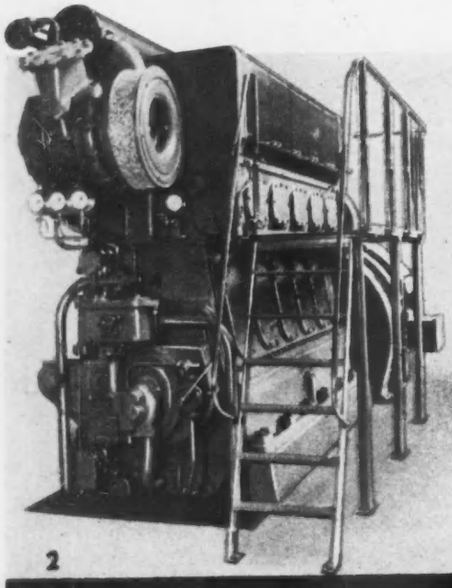

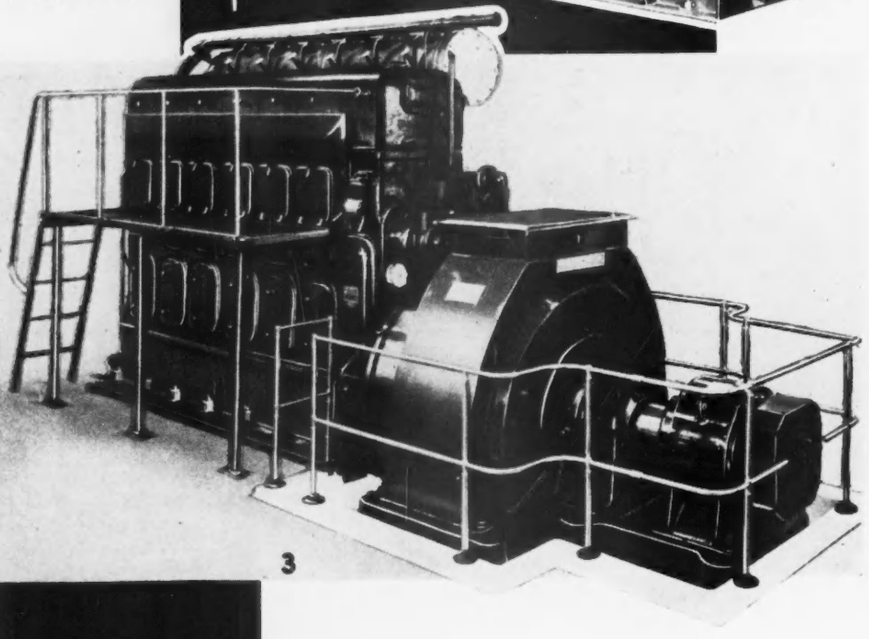

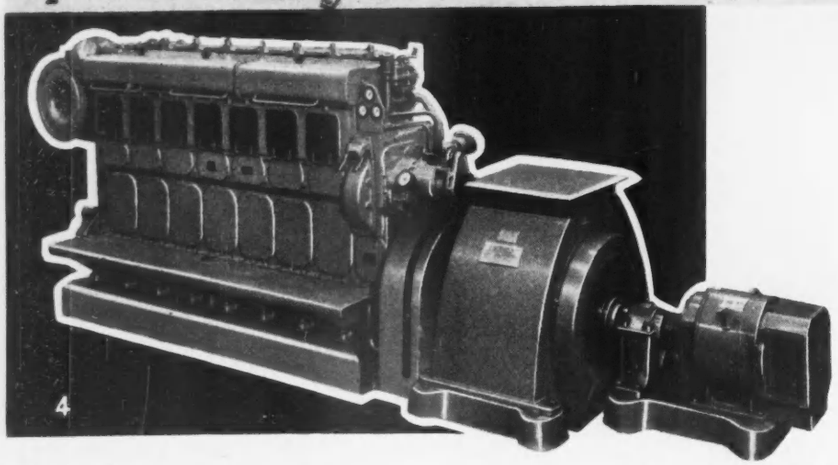

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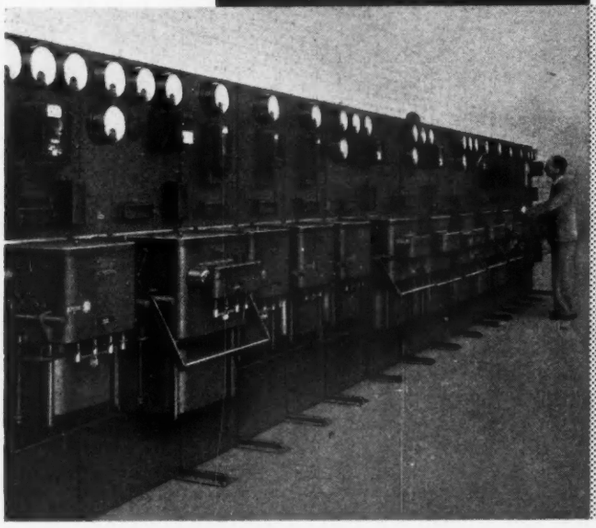
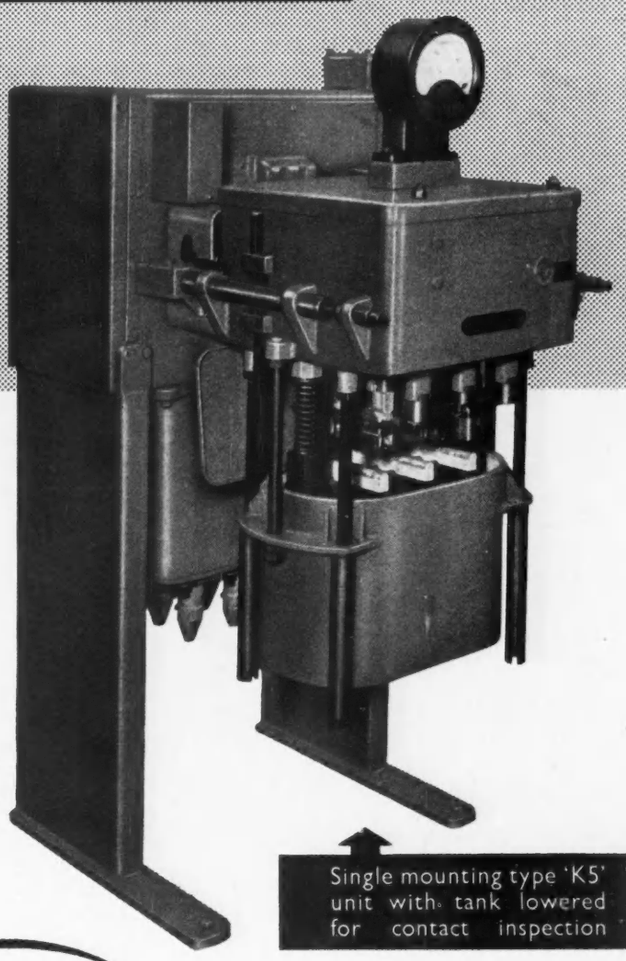


Switchboard consisting of types 'KC6' and 'KC4' units



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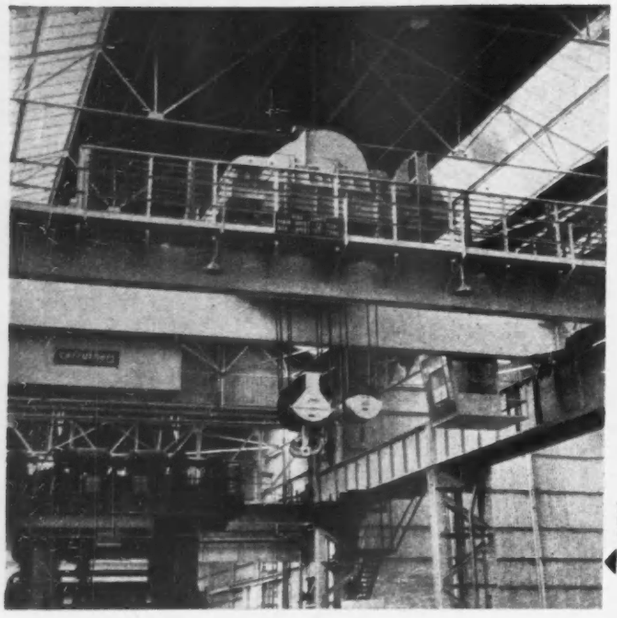

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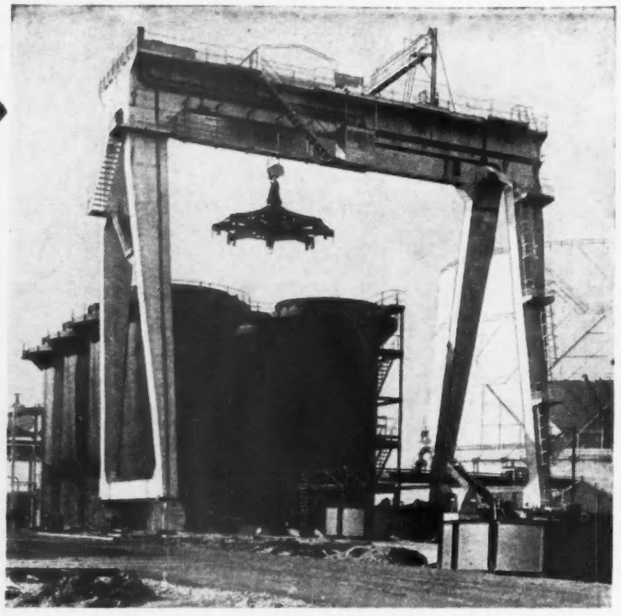

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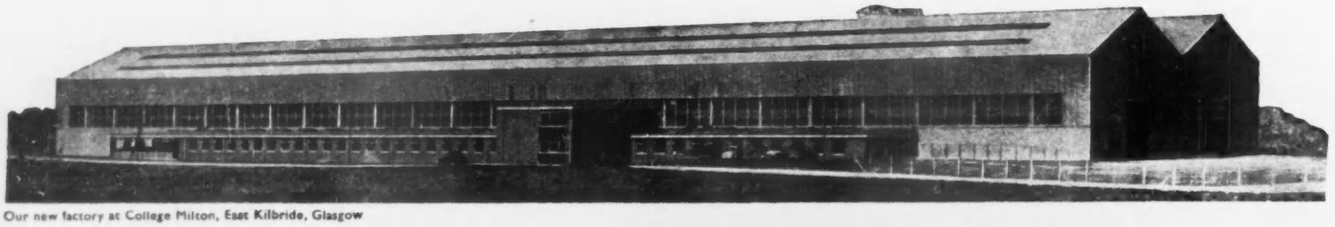

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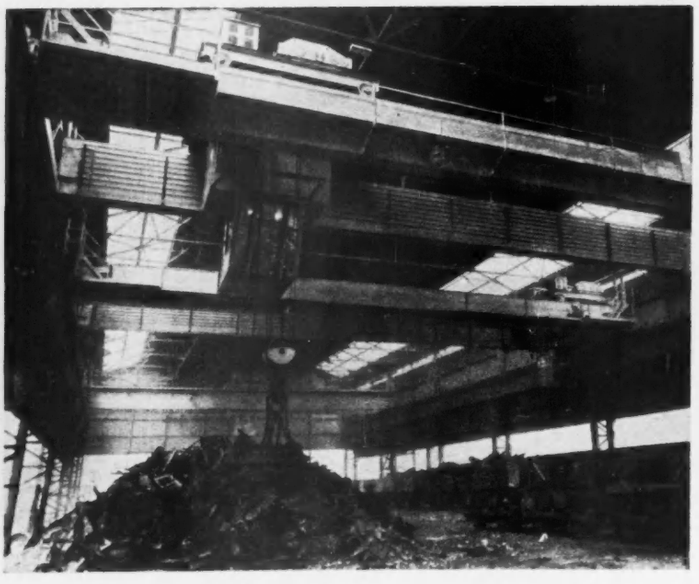

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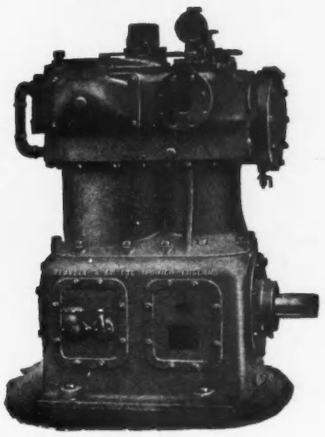

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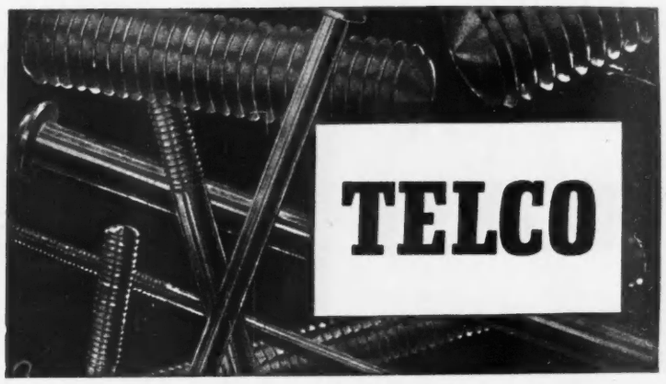

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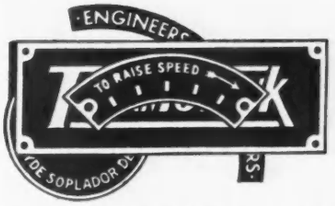

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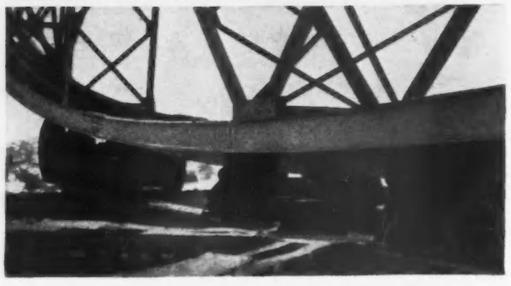
The gigantic steel structure has two 180ft. towers. These carry the 250ft. diameter bowl weighing 750 tons which can be tilted into a vertical position in either direction, or completely inverted.

The telescope has the equivalent of both a foot brake and a parking brake. The foot brake, lined with Ferodo MR.41 friction material, operates through four pairs of lorry wheels on standard transport axles, turned upside down so that the wheels press against the 300ft. diameter 'bicycle wheel' stabilising track fixed behind the reflector bowl.

The parking brake is the largest disc brake in the world, designed to hold the massive revolving bowl firmly in position even in gale-force winds. It consists of two jack-operated clamps mounted in tandem and lined with 32" x 6" strips of Ferodo BA material.

Ferodo friction materials have been proved in industry to give the smoothest, safest stopping power. *If you have a friction problem*—as the designers of the Jodrell Bank Radio Telescope had—why not call in Ferodo?



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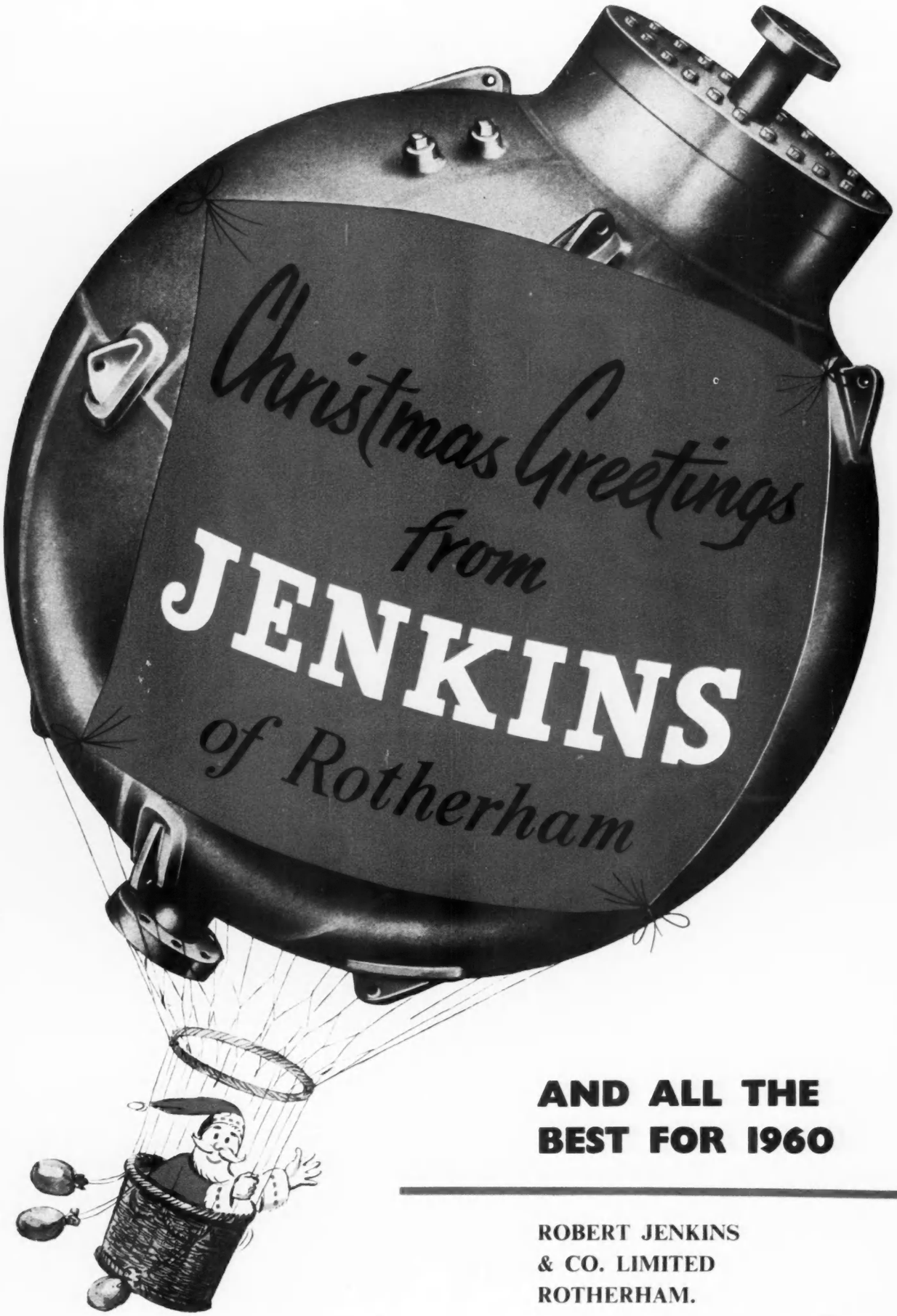

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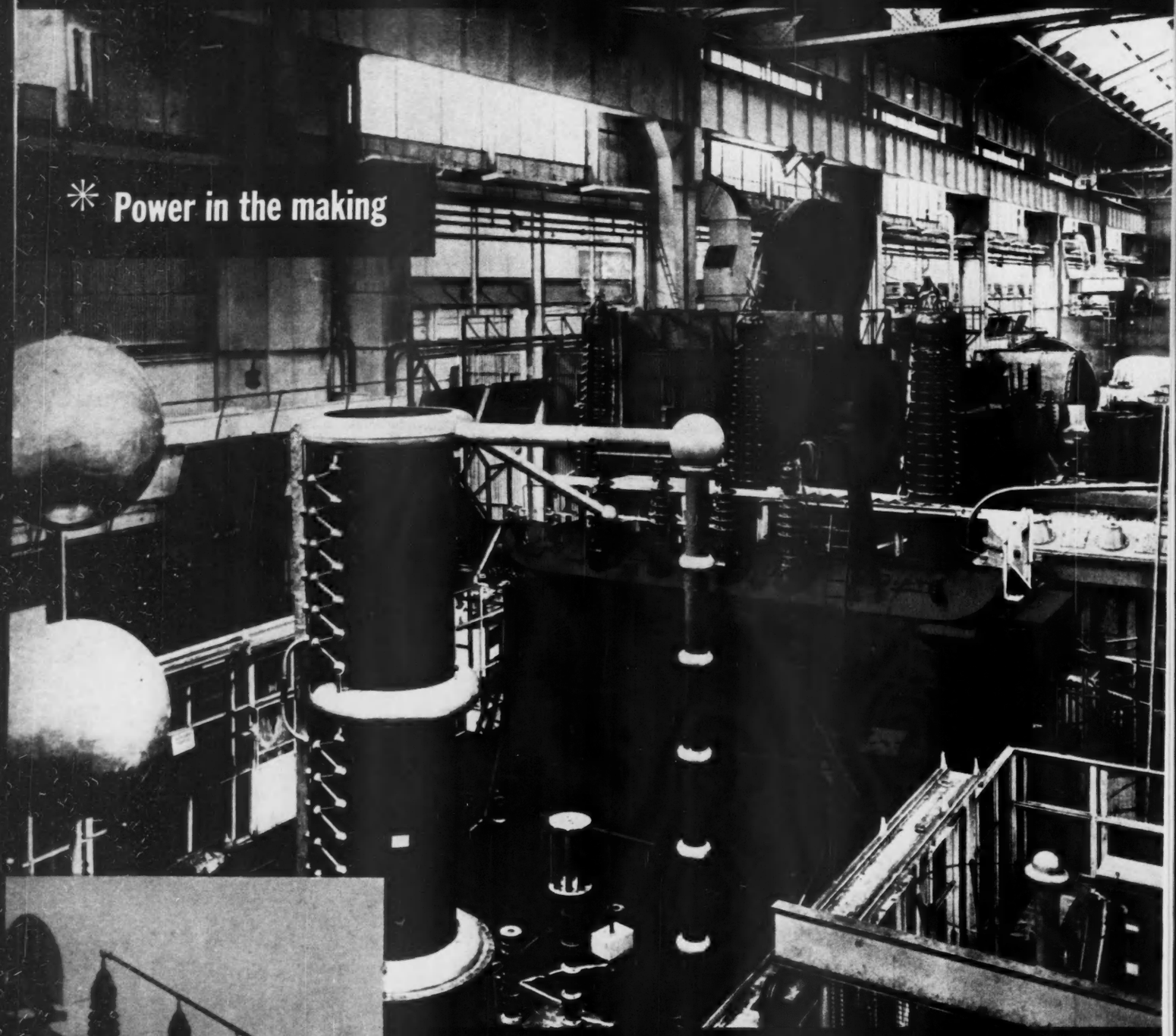

The impulse test plant shown here with a 120 MVA transformer on test is rated at 2½ million volts at a stored energy of 60 kW secs.

The autoclave plant behind, used for vacuum drying and oil impregnating processes, is capable of fully enclosing the largest tank yet manufactured by PARSONS.

✳ Transformers have been increased in size over the years to meet the demands dictated by the growth of power systems. Always during this time PARSONS have produced the larger types of transformers. In keeping with these developments PARSONS have installed manufacturing and testing plant to produce power transformers of the highest voltages and ratings.

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Type	No. of cylinders Arrangement	Output P.S (DIN)	Speedrange R. P. M.	Cyl. Bore ins.	Stroke ins.	Piston displacement cu. ins.	Weight approx. lbs.
M 202 B	2 / S	35— 55	750—1200	5 1/2	8 1/4	394.8	1665
M 203 B	3 / S	54— 96	750—1200	5 1/2	8 1/4	591.9	2150
M 204 B	4 / S	72— 126	750—1200	5 1/2	8 1/4	789.0	2715
OM 636	4 / S	17— 35	1500—3000	2 15/16	3 15/16	107.8	495
OM 312	6 / S	47— 77	1500—2400	3 9/16	4 1/4	279.5	990
OM 321	6 / S	55— 94	1500—2600	3 1/4	4 1/4	311.2	1025
OM 315	6 / S	80— 124	1200—1800	4 7/16	5 1/2	505.0	1875
OM 326	6 / S	97— 155	1200—1800	5 1/64	5 1/2	660.0	1720
MB 846 A	6 / S	114— 250	750—1500	5 7/8	7 1/2	1230.2	3860
MB 846 B	6 / L	114— 250	750—1500	5 7/8	7 1/2	1230.2	3970
MB 846 Ab[1])	6 / S	148— 320	750—1500	5 7/8	7 1/2	1230.2	4080
MB 846 Bb[1])	6 / L	148— 320	750—1500	5 7/8	7 1/2	1230.2	4200
MB 846 Ad[2])	6 / S	148— 320	750—1500	5 7/8	7 1/2	1230.2	4200
MB 836 B	6 / S	230— 350	1000—1500	6 7/8	8 1/16	1806.3	4330
MB 836 Bb[1])	6 / S	305— 500	1000—1500	6 7/8	8 1/16	1806.3	4830
MB 836 Db[3])	6 / S	370— 650	1000—1500	6 7/8	8 1/16	1806.3	5050
MB 820 B	12 / SV	460— 700	1000—1500	6 7/8	8 1/16	3612.6	6180
MB 820 Bb[1])	12 / SV	610—1000	1000—1500	6 7/8	8 1/16	3612.6	6900
MB 820 Db[3])	12 / SV	770—1350	1000—1500	6 7/8	8 1/16	3612.6	7240
MB 837 A	8 / SV	165— 440	850—2000	6 1/2	6 7/8	1825	2940
MB 837 Aa[1])	8 / SV	240— 550	850—2000	6 1/2	6 7/8	1825	3020
MB 839 Ab[1])	16 / SV	1145—1800	1000—1500	7 1/2	9 1/16	6380	11020
MB 839 Bb[3])	16 / SV	1380—2350	1000—1500	7 1/2	9 1/16	6380	11450
MB 518 [1])	20 / SV	3000	1720	7 5/16	9 13/16	8201.5	10550

S = vertical; L = horizontal; V = vee type; [1]) = supercharged; [2]) = supercharged and with boost intercooling
[3]) = with high boosting and boost intercooling.

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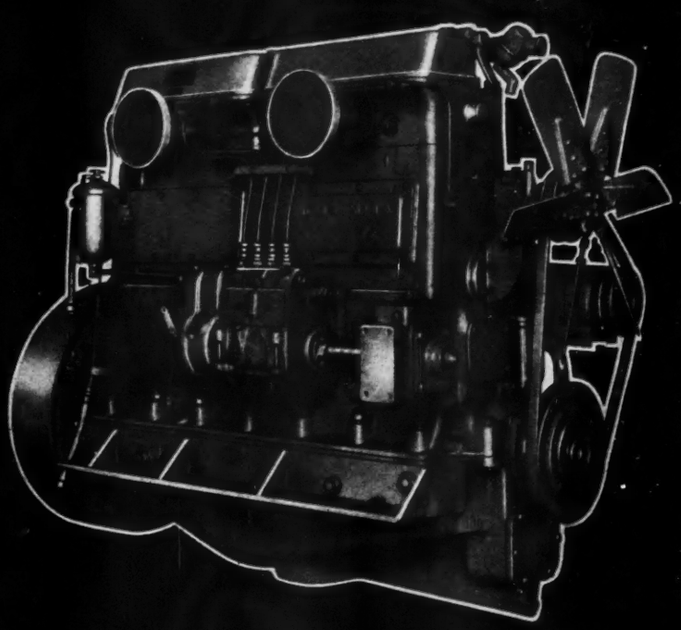

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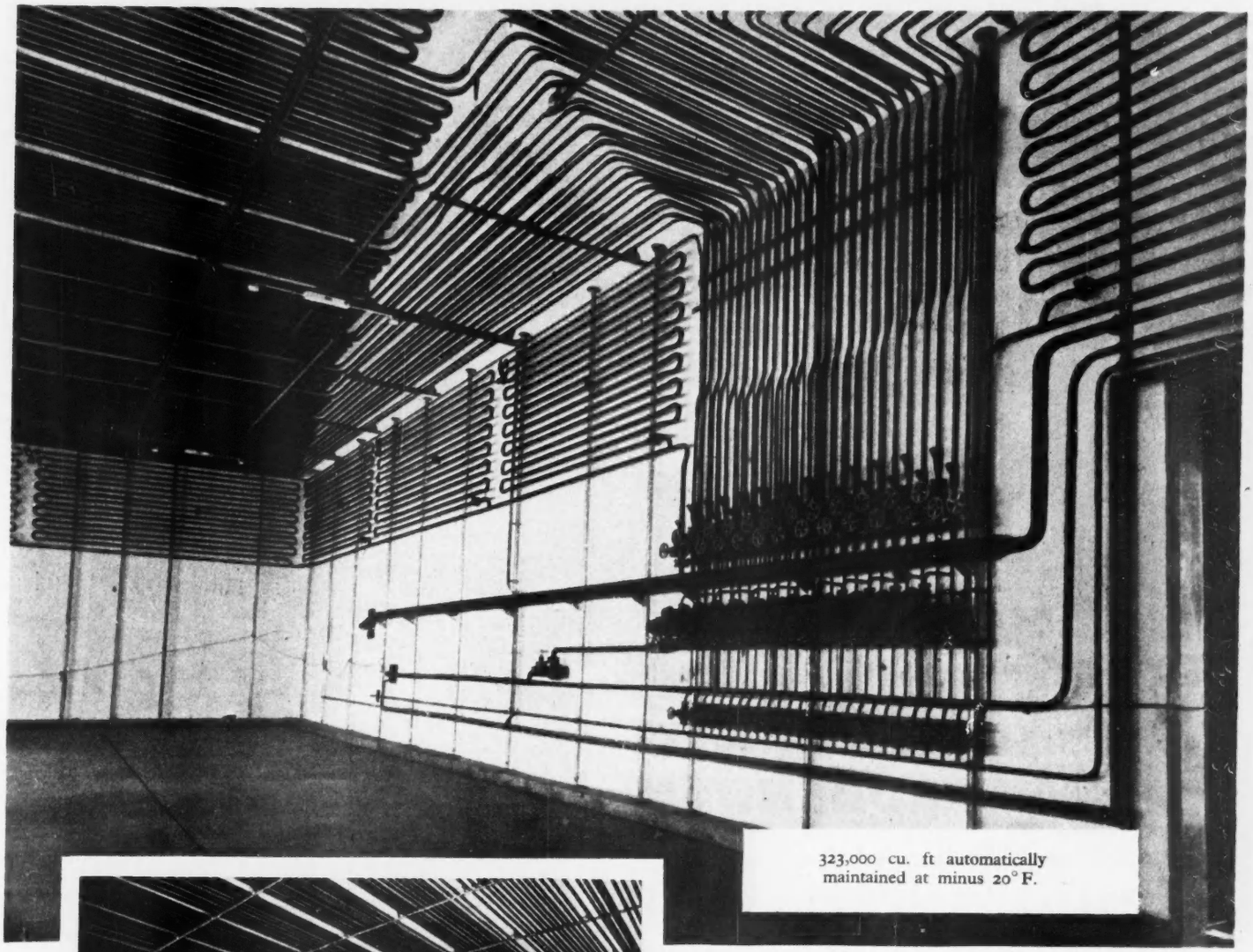
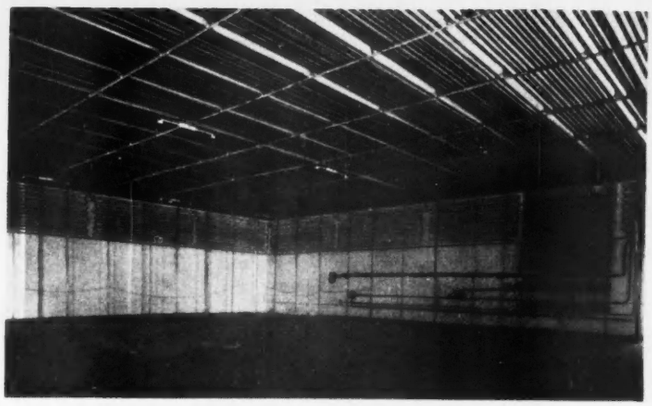


323,000 cu. ft automatically maintained at minus 20° F.



The photograph illustrates one of three exceptionally large storage chambers for quick-frozen fish. J. & E. Hall have carried out the pipe work and equipped three of these chambers for Chr. Salvensen & Co., Grimsby, providing a total capacity of 323,000 cu. ft ; the largest measures 116ft long × 72ft wide × 19ft 6in high. Temperature in the chambers is maintained at —20° F by two J. & E. Hall compound ammonia compressors. Each unit is powered by a 120 h.p. electric motor, and a third and similar machine is installed as standby. The whole plant is completely automatic in operation.

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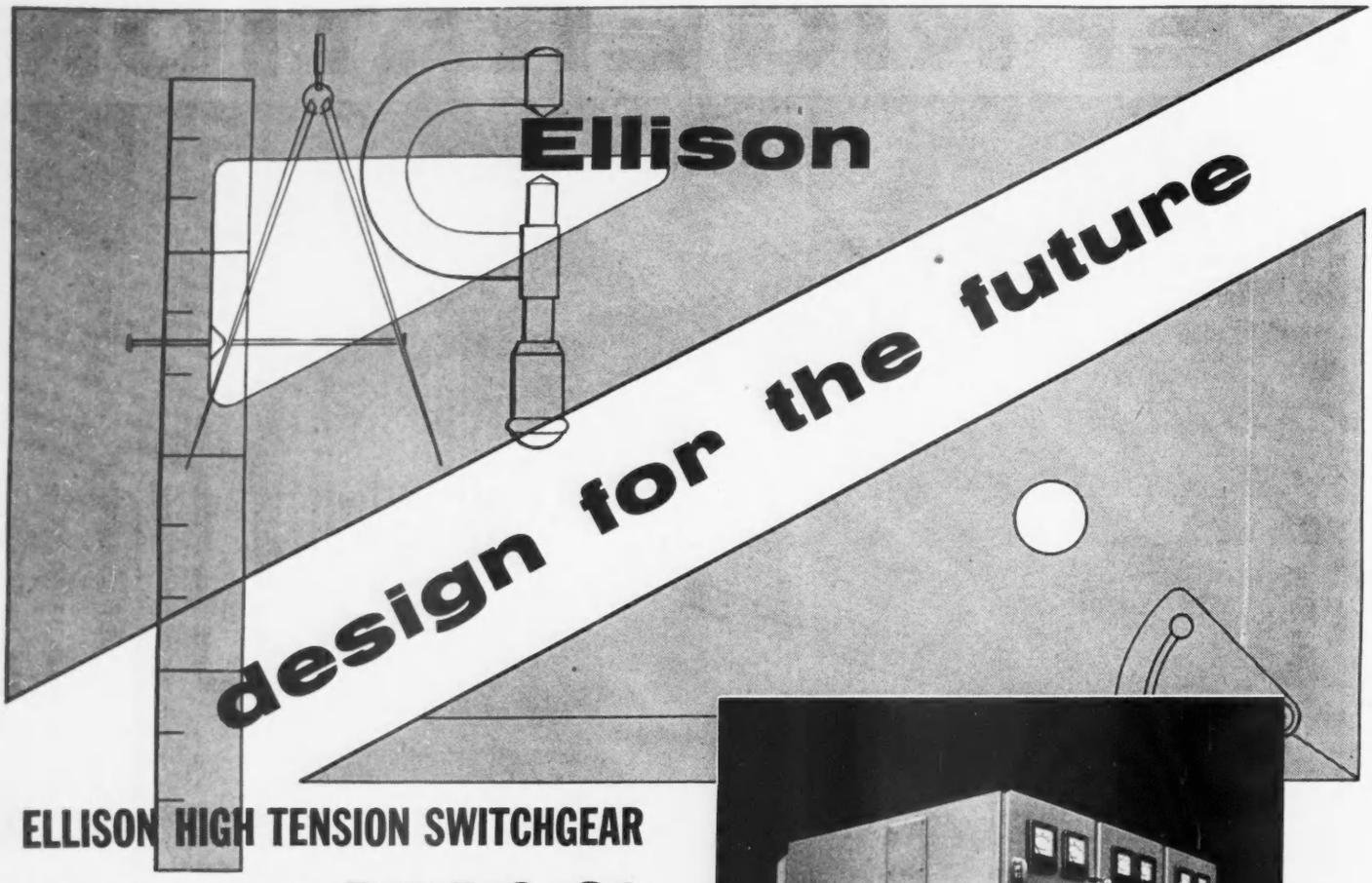

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complies with B.E.B.S.-S2 250 MVA ADDENDUM

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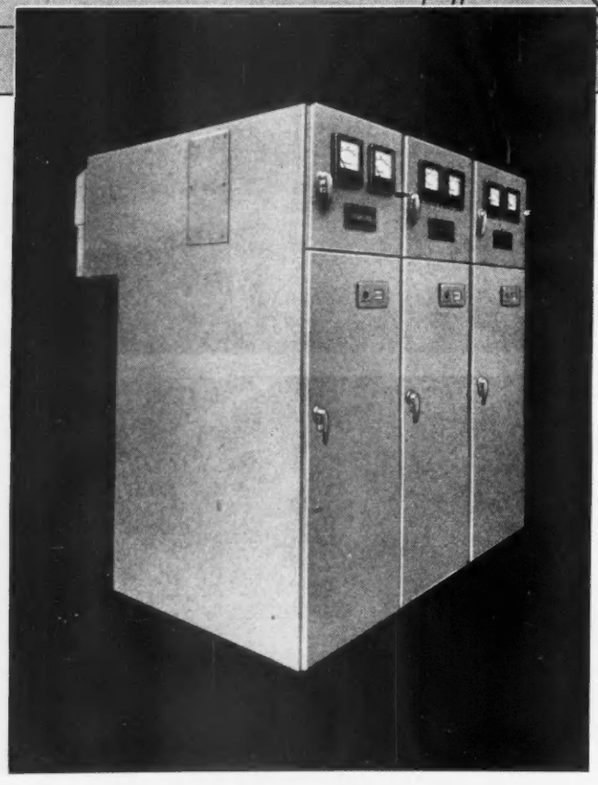

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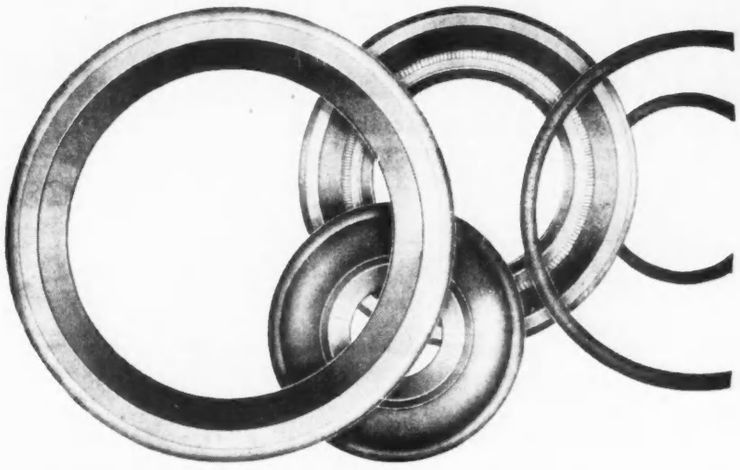

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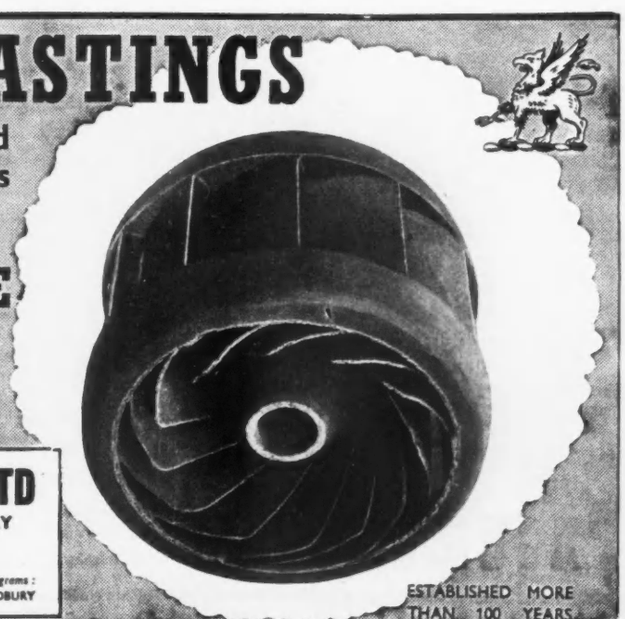

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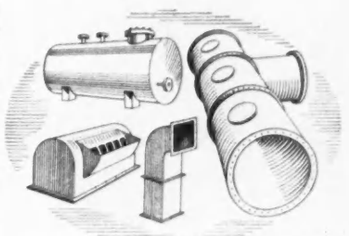

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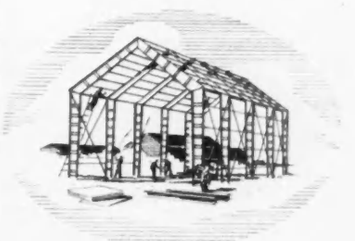

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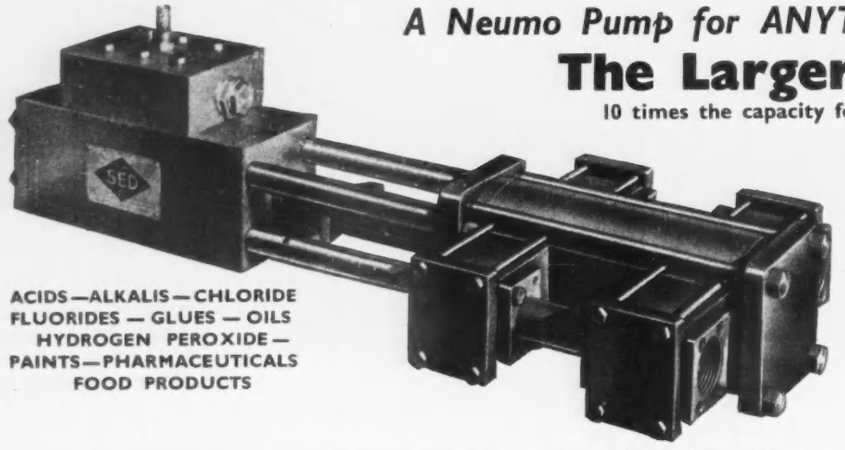

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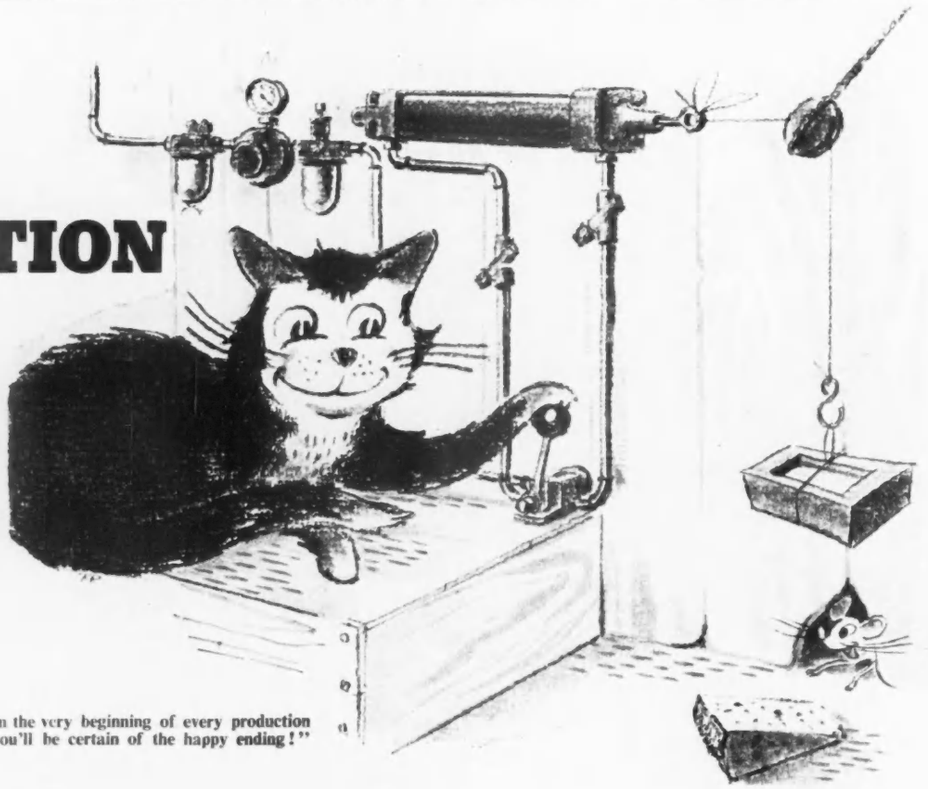

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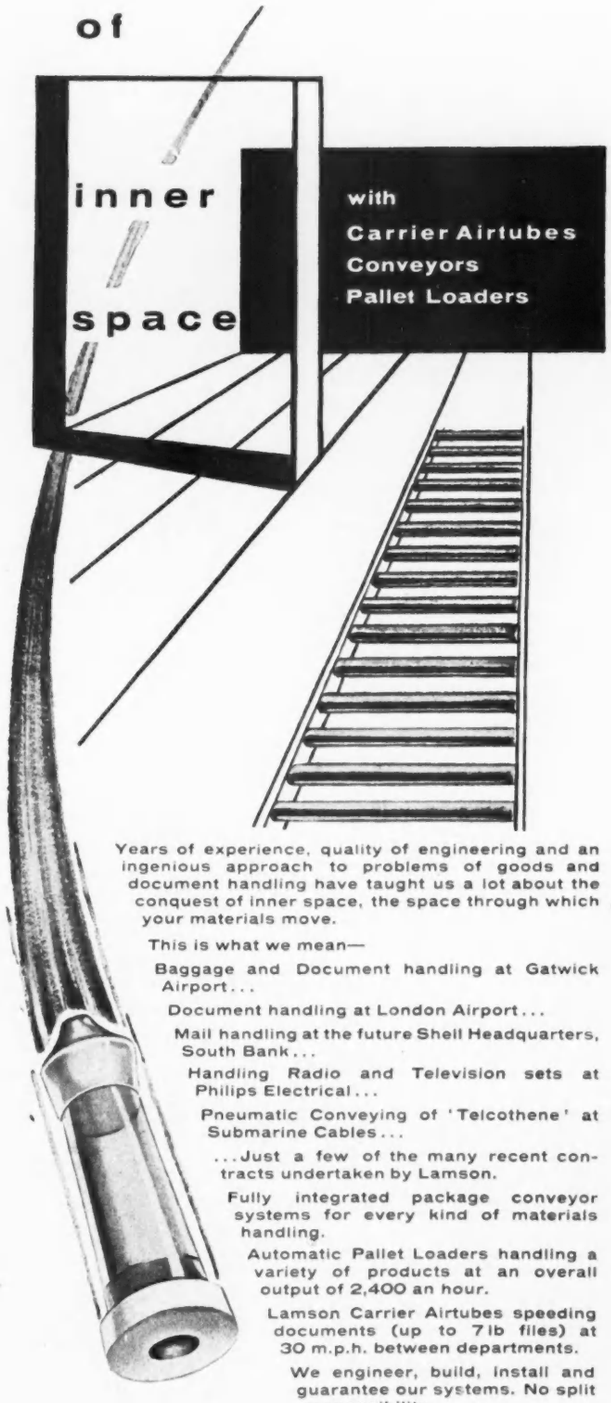

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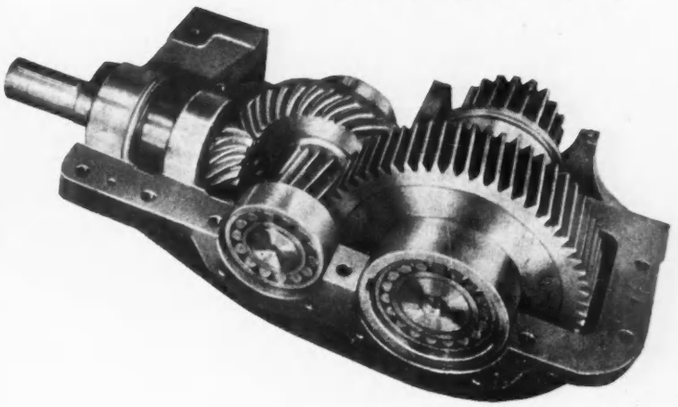

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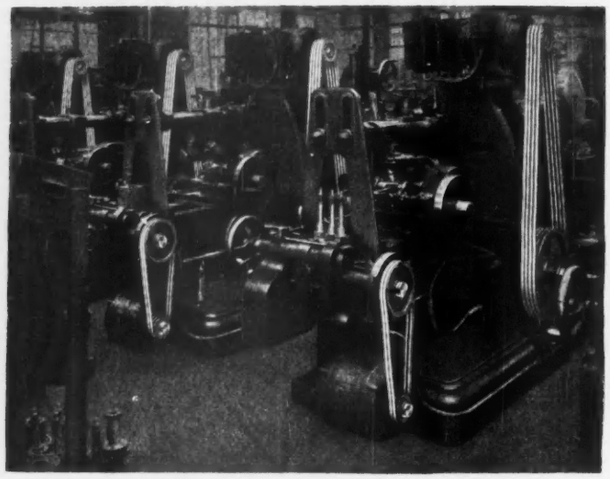

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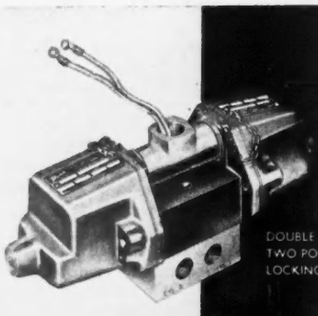

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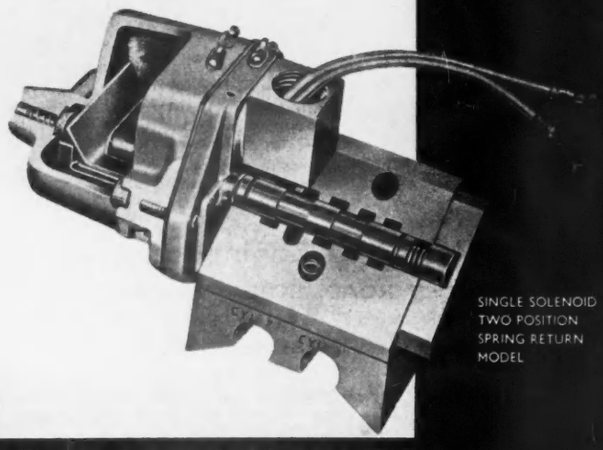

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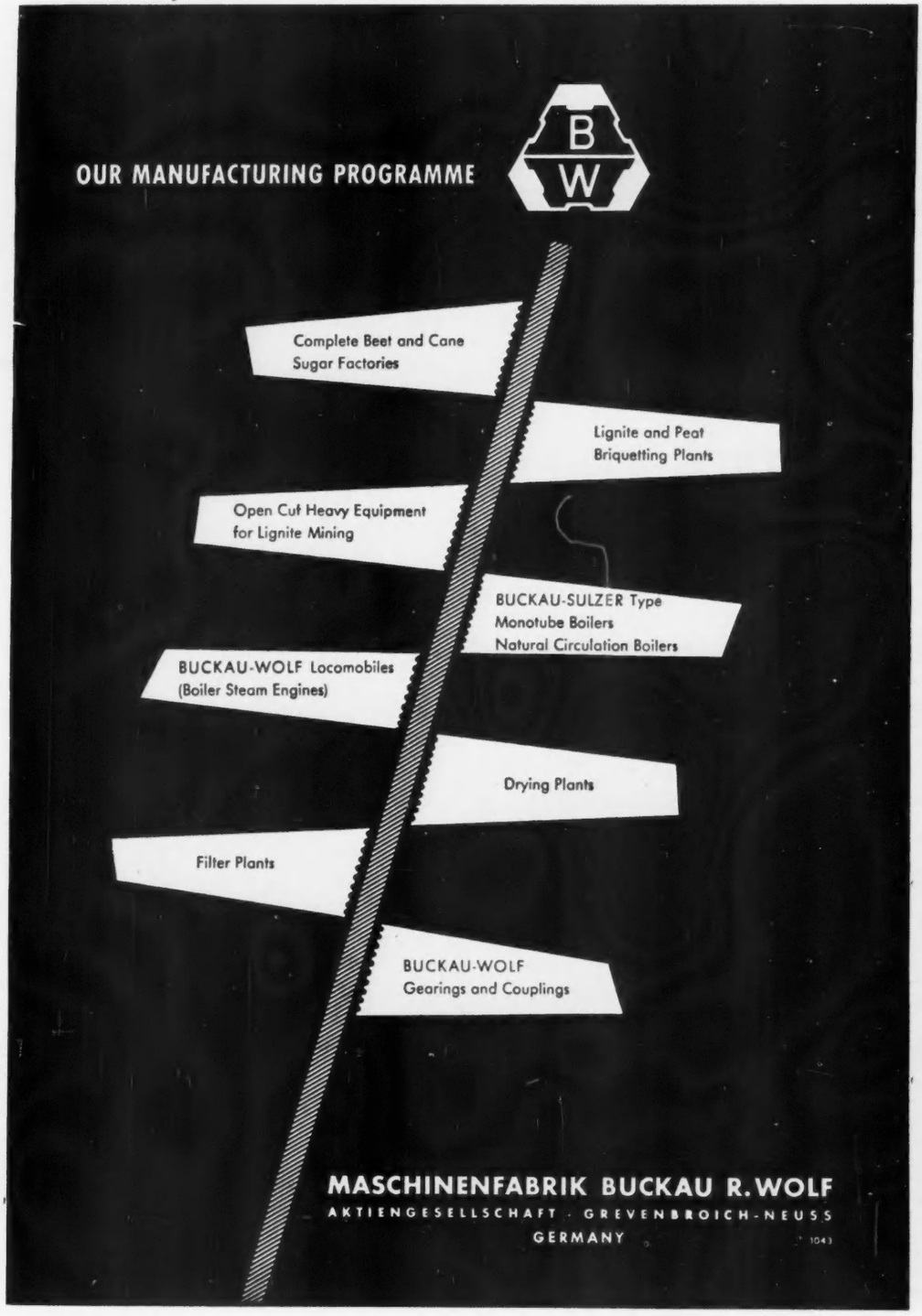

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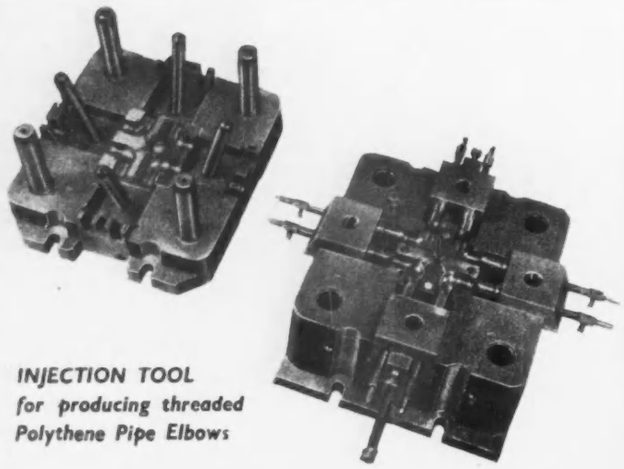

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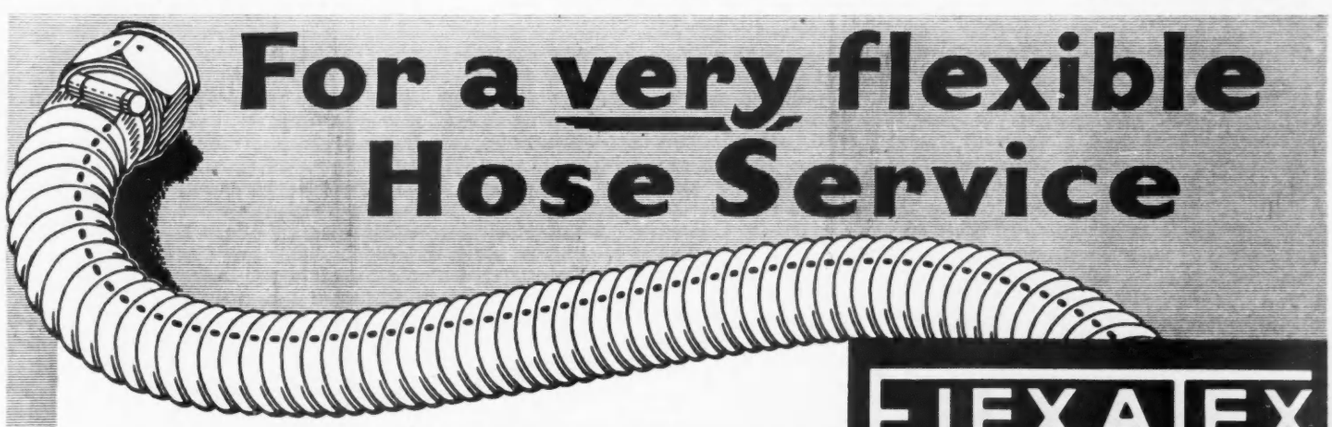

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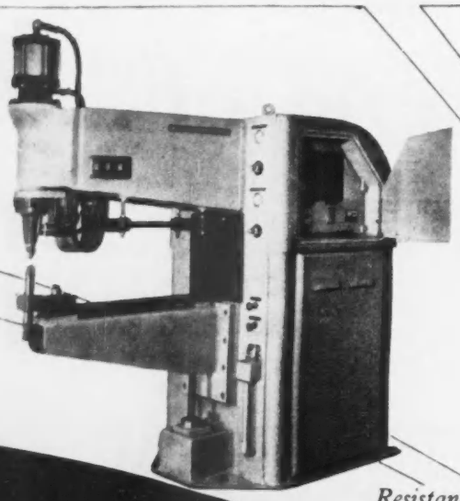
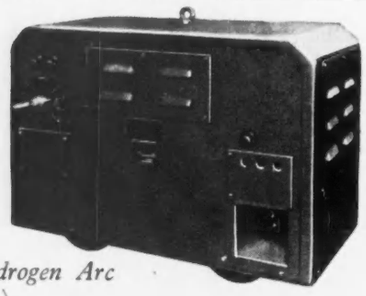


Resistance



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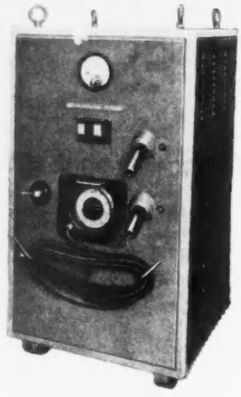

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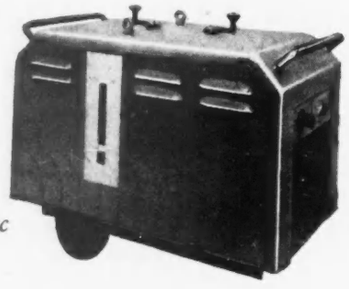

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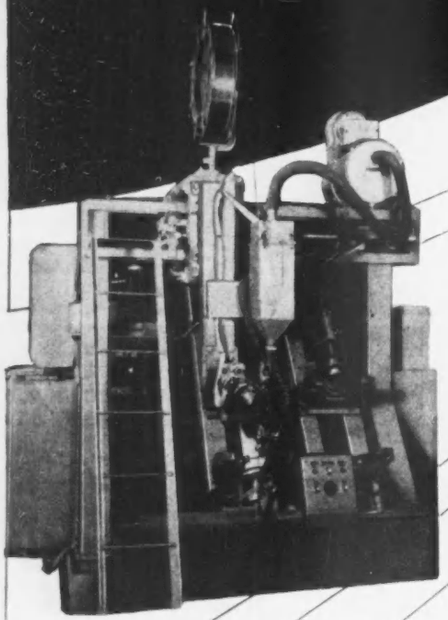

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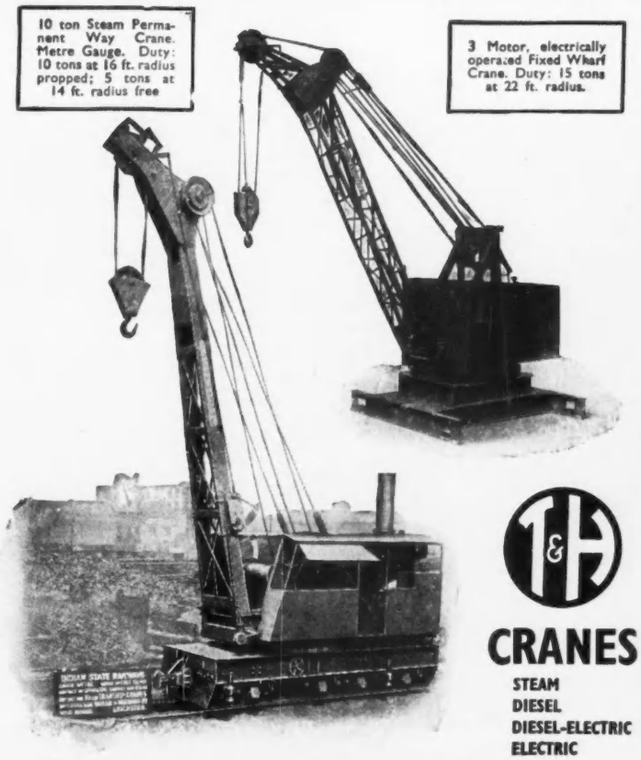

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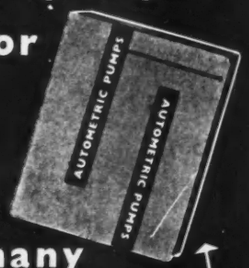

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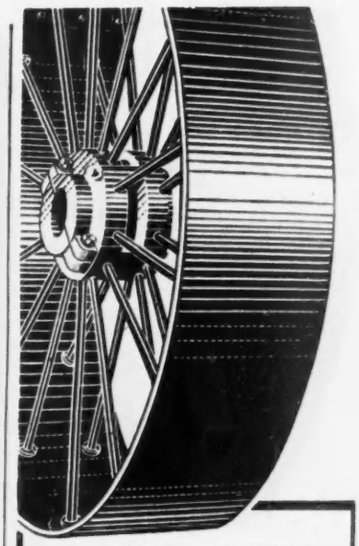

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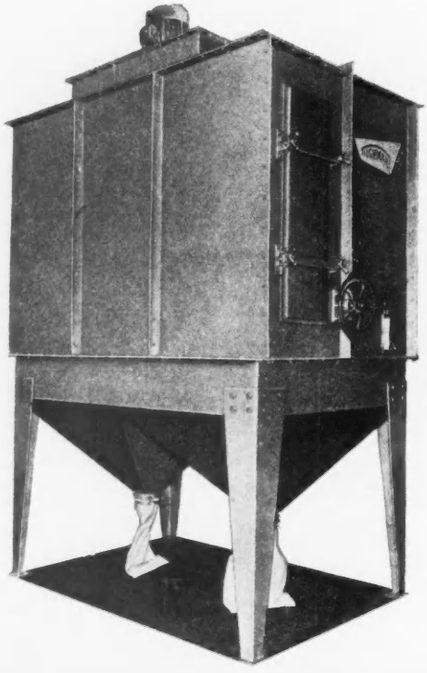

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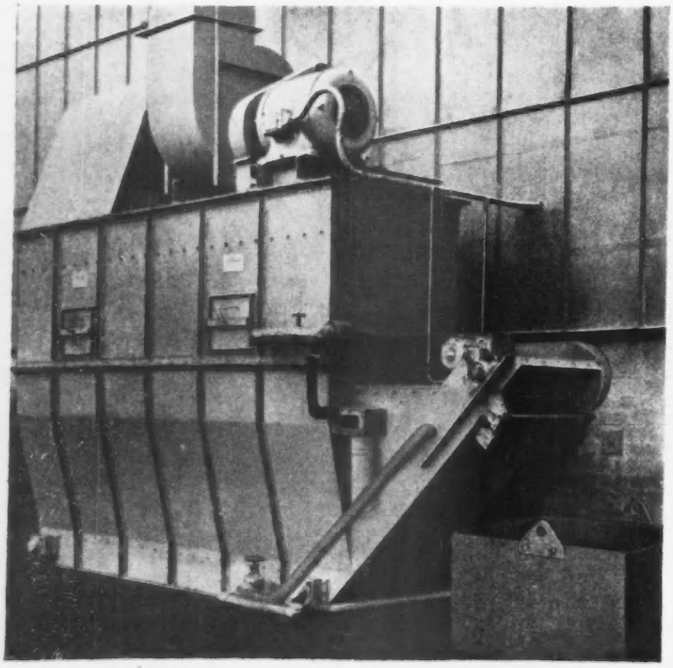

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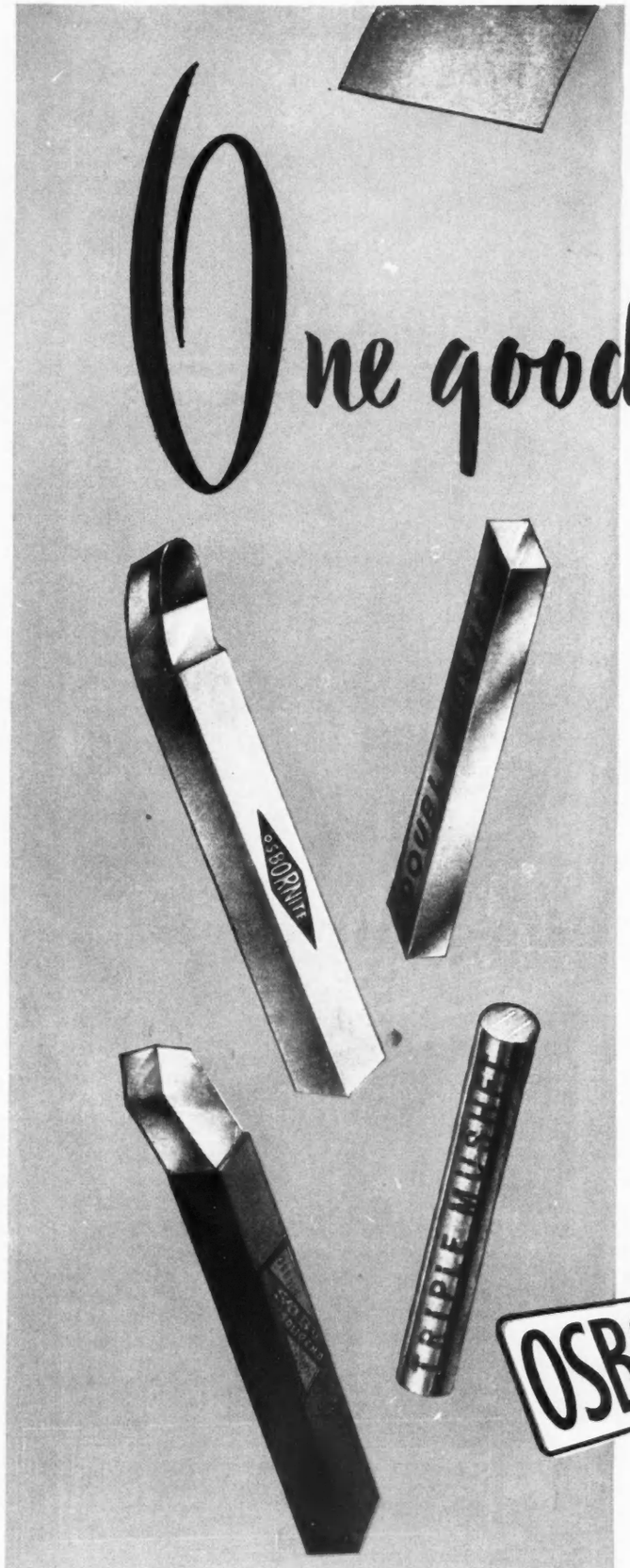

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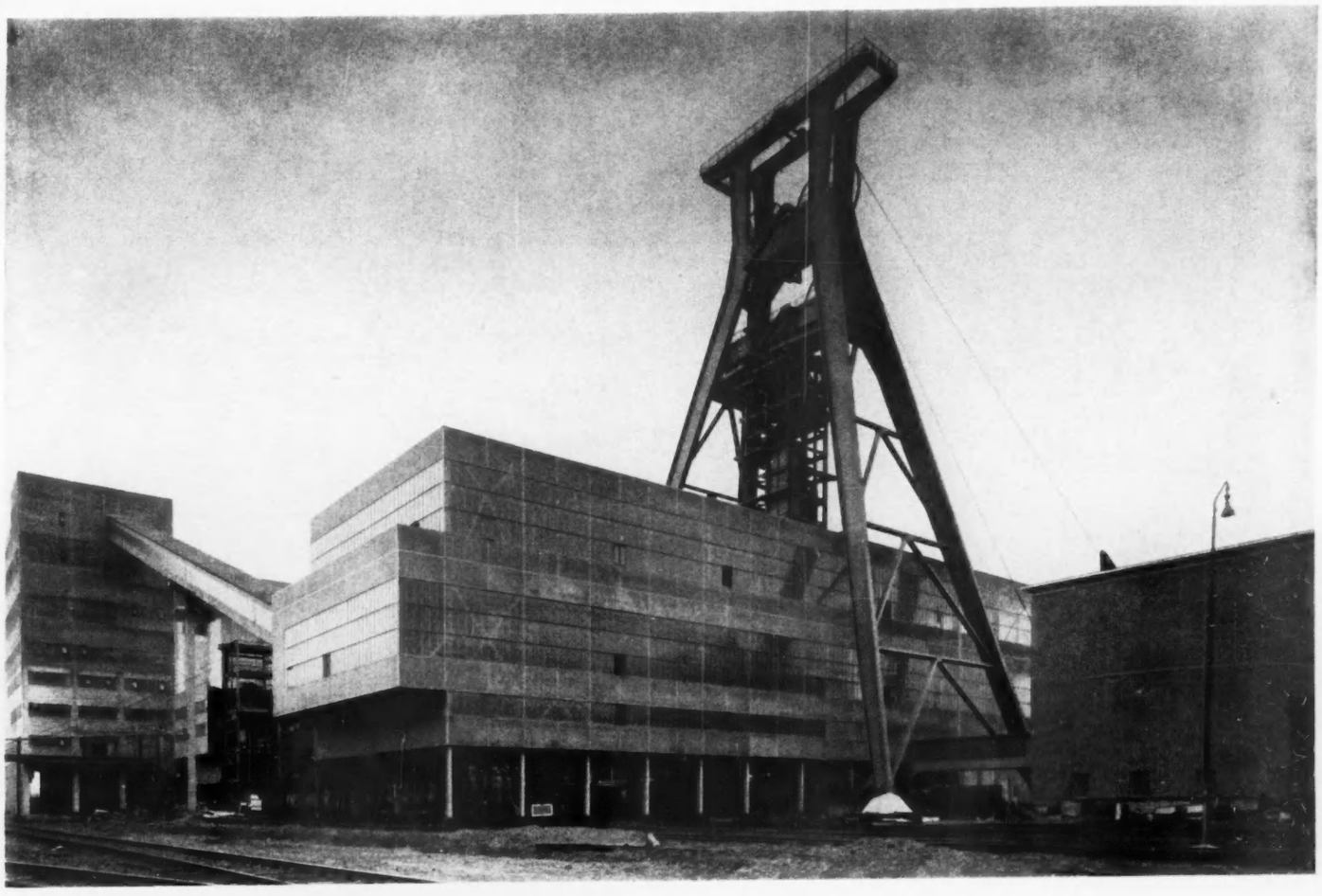

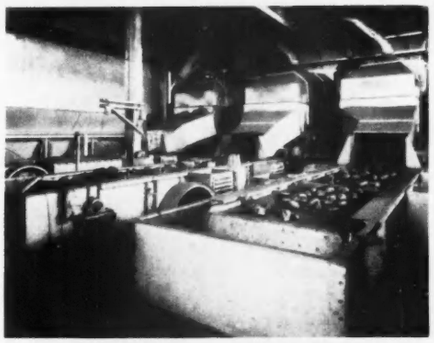

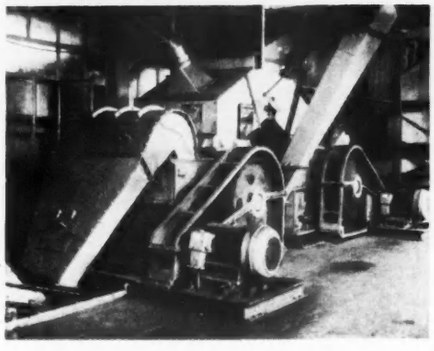

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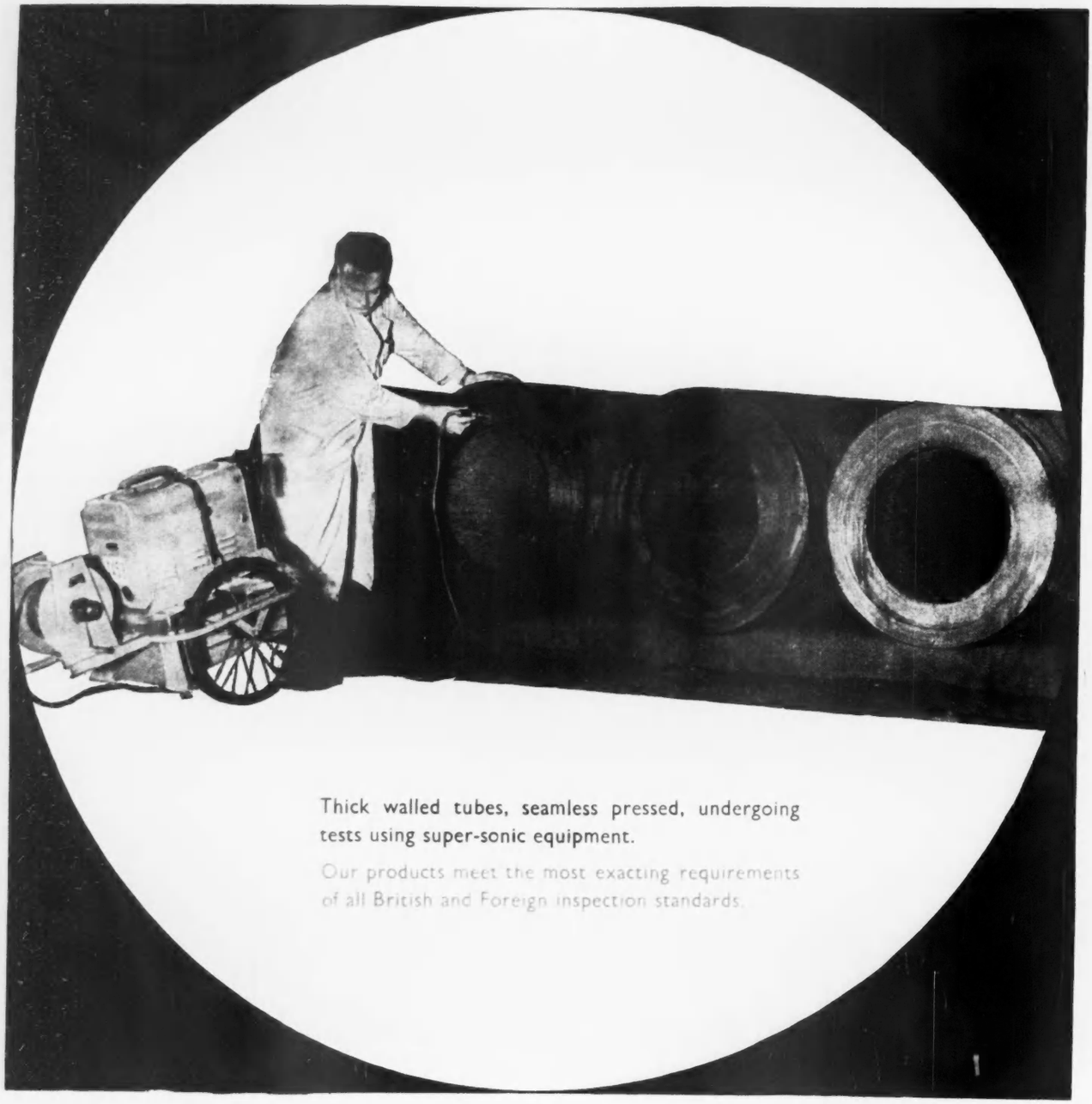

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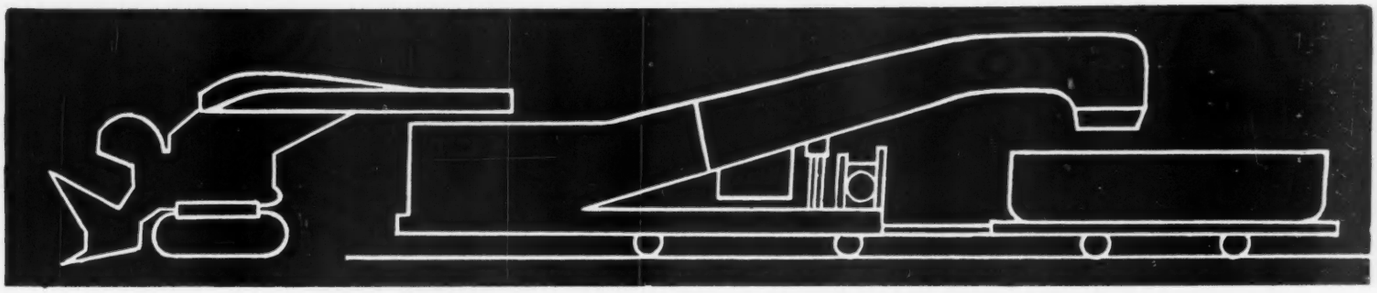

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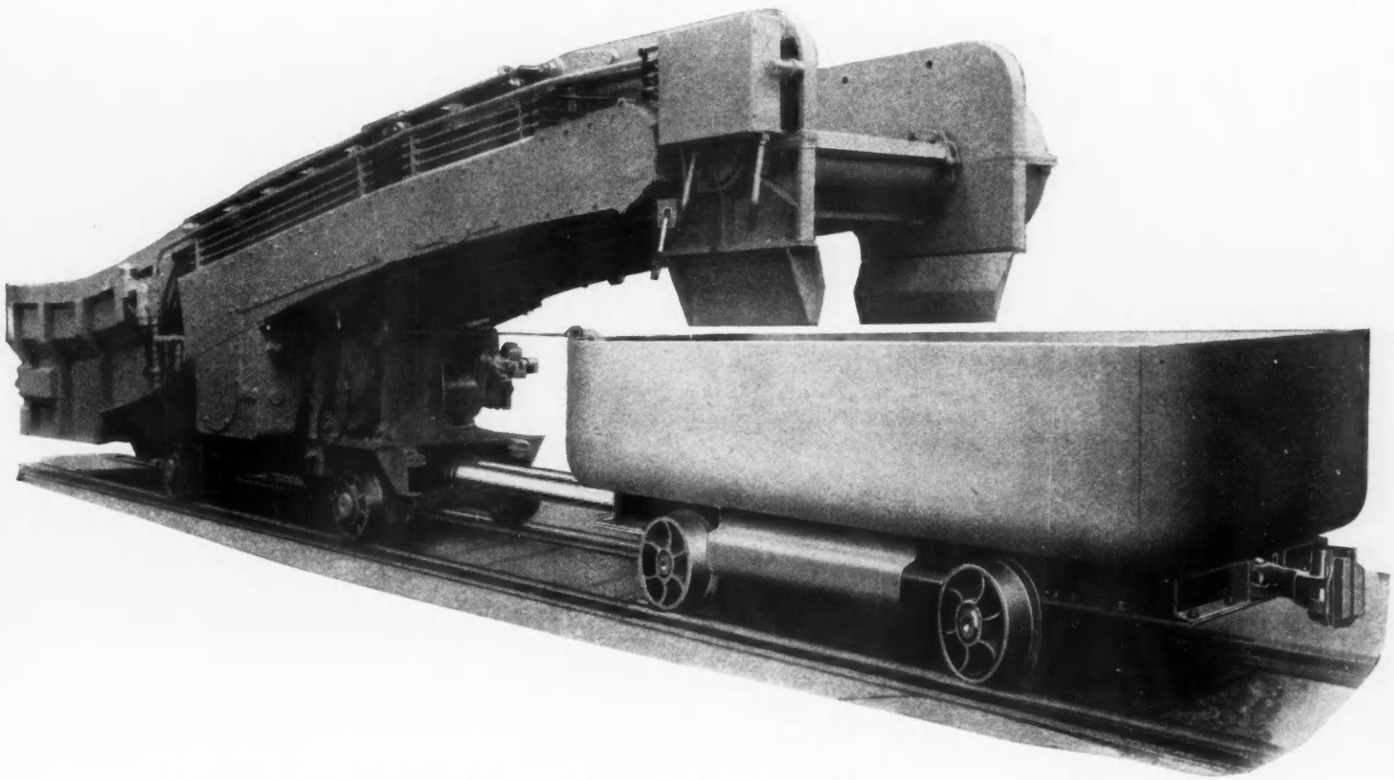

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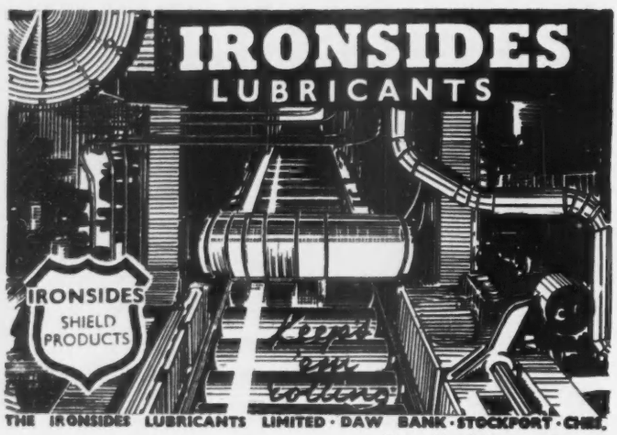

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THE ENGINEER

No. 5422 DECEMBER 25, 1959 VOL. 208

TENDERS FOR TANKER NUCLEAR REACTORS

The prospects of British participation in the development of nuclear propulsion of merchant ships advanced by a stage a week ago when Mr. Marples, the Minister of Transport, announced that the Government had decided to accept the recommendation of the Galbraith committee. This committee, which was set up in 1957 to consider the application of nuclear power to ships, has recommended that tenders should be invited from " selected firms " for two kinds of nuclear reactor (one the boiling-water reactor and the other the organic-liquid-moderated reactor) to be installed in a tanker of 65,000 deadweight tons. Mr. Marples went on to say that invitations to tender would be issued very shortly.

The statement is welcome as far as it goes, but it leaves a number of questions unanswered. For instance, which are the " selected firms " that are to be invited to tender ? Will they be limited to those that submitted to the Galbraith committee designs based on the boiling-water and the organic-liquid-moderated reactor ? Presumably not, for there is at least one new potential entrant in the field. It will be recalled that the original proposals considered by the Galbraith committee included a closed-cycle boiling-water reactor system by Mitchell Engineering, Ltd., and Fairfield Shipbuilding and Engineering Company, Ltd.; a direct-cycle natural-circulation boiling-water reactor system by A.E.I.-John Thompson Nuclear Engineering Company, Ltd.; and an organic liquid-moderated reactor system by Hawker Siddeley Nuclear Power Company, Ltd. More recently The English Electric Company, Ltd., through an agreement for collaboration with the Atomics International Division of North American Aviation Inc., has become actively interested in the organic-liquid-moderated reactor as a system applicable to small nuclear power stations as well as to marine propulsion. In both of the recommended reactor systems, therefore, there is scope for competitive tendering by British firms.

The choice of a 65,000-ton tanker for the proposed installation calls for little comment. A large tanker, with its normal operational régime of long trips with very rapid turn round of twenty-four hours or so, provides the ideal medium for trying out nuclear propulsion which is characterised by comparatively high capital cost and low operating costs. Tankers of 60,000 or 65,000 tons are on order or projected by British oil companies and might be suitable for propulsion by one of the proposed reactor systems. However, the all-important matter that remains to be decided, while the tenders are being prepared and considered, is that of the financial basis upon which the shipping and shipbuilding industries may be expected to participate in the arrangements for building and operating a nuclear propelled ship. Government aid of some kind may well be necessary for such a project.

The Minister's statement that negotiations with these industries " will continue " during the tendering stage gives an indication, we hope, of the sense of urgency that should attend these negotiations, bearing in mind the impression gained from the recent Hamburg conference, that other countries, notably West Germany, may be ahead of Great Britain in the application of nuclear marine propulsion.

POLICY FOR SPACE ROCKETS

The major matter of interest to engineers in the annual report of the Advisory Council on Scientific Policy issued last week, is an expression of the Council's opinions about space research. During the past year, it will be remembered, an agreement was reached with the U.S. Government under which the U.S. National Aeronautics and Space Administration will provide space in a series of satellites to be launched over a period of three to four years for a number of British made and designed instruments. These instruments will be designed to carry out a scientific programme under the general supervision of the British National Committee for Space Research established by the Royal Society. That agreement certainly gave much satisfaction to scientists in this country. But engineers looked wryly at it. For their only access to the peculiar engineering problems of placing a satellite in orbit around the earth or the moon (or any other planet) or sending men into space are now apparently to be restricted to design studies into the possibilities of adapting British military rockets such as " Black Knight " and " Blue Streak " for the purpose. It really is not a very attractive prospect for an up-and-coming rocket engineer to be engaged on a study which may very likely never result in the production of any hardware and which additionally must be covered by a veil of secrecy !

It is, of course, easy enough to see the arguments of the Council. To contribute to space research on a scale anywhere near comparable with that of the U.S.A. and U.S.S.R. would make a high demand upon our limited scientific resources and far too high a demand upon our financial resources to be bearable. The Council therefore finds satisfaction in an agreement that permits British scientists to contribute to space research at a shoestring cost whilst limiting expense on rocket researches to earthbound missiles. But for our part we cannot help thinking that the Council may be too overweighted by professors and research workers to come to a completely objective conclusion upon the point. There must surely be an advantage to any country whose engineers are working upon problems which lie at the extremity of the technologically possible as many rocket research problems do ; and British engineers ought, we feel, to be engaged on such work with the exciting prospect of testing out real hardware. Some way out of the dilemma ought to be sought. The Council sees the way out in an internationally based approach to the whole field, which is surely right enough. But, as engineers, we cannot think it a satisfactory international approach that under the present agreement all the engineering side—other than the quite minor effort involved in instrumentation—is left with the Americans ! If—because it is felt in

the U.S.A. that secrecy about rocket developments must be preserved—British engineers are to be denied the experience of contributing to the design and operation of space rockets in that country, which would a be true international effort in the field, then, we suggest, an attempt should be made to create some organisation in Western Europe, within which British (and Commonwealth) engineers, as well as scientists, could collaborate in a complete space research programme. We suggest that, as no air of secrecy should shroud the doings of such an organisation, it would conduct its researches more cheaply than either the Americans or the Russians ; and that for the same reason it could rapidly catch up upon and soon surpass their performances. For, as the history of nuclear power has shown, the bringing out into the open of facts and theories initially held secret can prove immensely stimulating to further advance.

SHORT TERM MEASURES AGAINST DROUGHT

Early this week the Minister of Housing and Local Government circularised water supply undertakings. The circular was sent out as a direct consequence of the difficulties experienced by certain authorities in maintaining supplies during the unusually dry weather last summer. The Minister, it remarks, " has been impressed by the way in which the great majority of undertakings were able to meet all the demands upon them without imposing restrictions on consumption or seeking powers to enable them to reduce compensation water or tap new sources." But for our part we cannot really think that one should be " impressed " merely because undertakings have for the most part, succeeded in doing what they were created to do ! In our view the situation that arose towards the end of the long drought was very disquieting. For though it is unusual for so little rain to fall in this country over so long a period it is by no means phenomenal and as we remarked last October water undertakings should surely work on the principle that supplies should only become straitened if an unusually dry winter is interposed between two dry summers. It is really deplorable that a single dry summer should have put any undertaking into a difficulty. However, it is satisfactory to see that the Minister, though " impressed " by the operation of most undertakings, is also disturbed by the failure and near failure of the few. He remarks " it is not without significance that some of the undertakings that have been in difficulties have not carried out or proposed to carry out any development of their resources since the war and have not undertaken the development recommended in the water supply surveys made in some cases ten years ago."

Reading between the lines there is a distinct suggestion in the circular that some supply undertakings were caught napping by the drought. Otherwise why should the Minister stress that they should " make as certain as possible that . . . reservoirs are full at the beginning of the 1960 summer season "; that they " should re-examine the timing of the steps which they must take if drought is threatened . . . continue and strengthen arrangements for mutual aid . . . and review stocks of plant available for emergency use "? It is also interesting that he should feel a need to stress the desirability of applying for orders for the reduction of compensation water flows at an early date in the winter or the early spring when rivers are still running reasonably high. At such a time the acquiescence of river boards, millers, &c., is much, of course, more easily obtained than it is at a later stage when a substantial fraction of the flow in the river, well below a reservoir, may be provided by the compensation water.

We cannot help thinking that this circular reinforces what we as well as many others have been writing and saying for several years. The drought was beaten in several areas only because neighbours of the affected undertaking were able to provide emergency supplies or to lend plant, &c. There is thereby created a strong suggestion that the storage capacity in this country is in reality ample to meet the demand even during the driest of dry summers. But what is lacking is proper planning and control of the utilisation of the stored water ; and the means of distribution are inadequate. It really is astonishing that there are still over 900 separate undertakings in this small country. It is far too many. The Ministry, it is true, is encouraging amalgamation amongst them, not without success either as there were no less than 1250 undertakings in 1945. But progress is painfully slow. Surely the time has come to organise water supply on regional lines within whole watersheds ; and as water will certainly have to pass easily across regional boundaries there should be central planning and control. Has not last summer's drought shown up the weaknesses and lack of economy of the existing arrangements ?

1960 DEFENCE WHITE PAPER

Russia's success in launching and guiding her satellites and the now universal realisation that the H-missile is a weapon of suicide suggest that Mr. Watkinson, when framing his 1960 Defence White Paper might well give more details of the part which our Armed Forces are to play under present defence planning. In existing circumstances there can be no alternative to basing our military plans on preventing rather than preparing for war. But in view of the very vulnerable position of this country—clearly set out in the 1957 Defence White Paper—the British people do not understand why both the United States and Russia, while following a similar policy in building up their retaliatory power, find it necessary also to provide themselves with conventional forces of immense size and power. Both countries are so vast in area that they no doubt anticipate a " broken back " period of warfare and this may well be the reason for the 300-odd oversea Soviet submarines. But it seems possible that Soviet planners have in mind a maritime war fought outside the Continent of Europe, developing from a localised campaign overseas.

There are several points in relation to both the tasks of our Fighting Services and the weapons they would use in a major war on which clarification is required. According to the Supreme Allied Commander, the Allied armies are not in Europe merely to prevent an unexpected *coup d'état* by the Soviet forces—a sudden occupation overnight of an enclave of Allied territory. They are there to hold up a major aggression long enough to make the Soviet leaders pause and think again of the consequences ; and they are being provided with tactical atomic weapons to compensate for lack of manpower. It is not clear why Soviet military planners are expected to require " second thoughts " or what advantage is given by atomic weapons possessed by both sides. Nor is it evident whether, when bombarding communications 100 miles behind the enemy lines and surrounded by villages and small towns, the nuclear weapon used would be described as tactical or strategical. But the plan is certainly not in line with the British Government's declared policy.

Again, in the case of the Royal Air Force, is not the air-launched guided powered bomb a better deterrent than the fixed land-based ballistic rocket ? The Americans

have successfully tested their 500-mile air-to-surface guided missile "Hound Dog" and a near-sonic V-bomber flying at 70,000ft and launching the missile 500 miles from the target should be reasonably safe from enemy aircraft defence. Unofficial reports from the United States suggest that their own intercontinental missiles can be relied on to land only within 15 miles of the target instead of within the 5 miles required to damage a "hard" or well-protected site. Is it not possible that Soviet rockets would be more accurate ? It is interesting to note in this connection that the Americans contemplate railway wagons as launching platforms for some of their new intercontinental rocket "Minuteman."

As for the Royal Navy, Government spokesmen in Parliament and the Navy's large ship contribution to N.A.T.O. of only two carriers and two cruisers leave no doubt that its primary function is "to bring power rapidly to bear in peace-time emergencies or limited hostilities." In the light of the premises on which our defence policy is based, this is perfectly logical ; though it will not be easy to persuade the taxpayer to provide money for new ships which are to fight only the Chinese and Hottentots. But if Britain is not to play her part during "the broken back" period of a major war, how does this fit in with the immense navies of the United States and Russia ? Why are the Americans still building carriers, cruisers, destroyers and frigates ? It is true that their carriers and new "Polaris" submarines are intended primarily to supplement their land-based retaliatory power. Indeed, the U.S. naval authorities are now asking for funds to arm their new atomic-powered cruiser and some of their existing cruisers partly with the "Polaris" rocket. But from the number and size of its ships, the United States Navy clearly anticipates having to safeguard supplies to Europe from attack by Soviet cruisers, armed raiders and submarines. Should not Britain build new ships similarly armed which, with the V-bomber and air-launched guided missile, would provide a mobile and safe deterrent, at much less expense than the land-based rocket with its very costly hard underground site ? She would then at least have the ships required to guard her communications in the wide oceans in the only kind of major war she is ever likely to have to face. The Minister of Defence may feel convinced that the "Polaris" rocket needs much more development before it can be regarded as an effective deterrent missile, launched from ships. If so, he would do well to say so, even at the risk of offending our American friends. The layman has no means of evaluating the various guided missiles now in service or under development.

NATIONAL RESEARCH AND DEVELOPMENT

As we write, the Report and Statement of Accounts of the National Research and Development Corporation lie before us. How the years fly past ! It seems only a year or two ago that we were welcoming the creation of this body—albeit not without expressing some doubts about the value it might turn out to have. Yet the present report deals with the tenth year of the life of the Corporation, which has therefore entered its second decade of work. In the present report, in contrast to the last, there is no general review of the Corporation's work or discussion of the benefit derived from it by the community. Instead, the report is almost wholly confined to short reports about the various development projects on which it is engaged. It is worthwhile mentioning some of them if only because the connection of the Corporation with certain research and development work is less widely recognised than it should be. There is, for example, the system of achieving economy in the frequency spectrum by transmitted television signals based upon proposals made by Professor Cherry, of the Imperial College of Science and Technology. An experimental system based on a thirty-line picture has, we learn, been constructed and a further system operating on 405 lines is being developed. The Corporation is supplying financial support. The Corporation has also made a contribution towards the cost of equipment intended to assess the value of a proposal by Professor Ford and Dr. Cameron, of the same college, for a rolling mill using rolls supported in hydrostatic bearings. The connection of the Corporation with the "Hovercraft" is, of course, well known. A subsidiary company entitled "Hovercraft Development, Ltd.," has been formed to carry on the interest of the Corporation in this project. Amongst other inventions and projects in which the Corporation is interested are a ditch cleaner, a pitch stabiliser for ships, computer controlled machine tools, electronic digital computers, an oil well drilling rig, a hydrogen-oxygen fuel cell, the towing of oil in flexible floating containers, a flowmeter working on ultrasonic principles, and variable speed induction motors.

One of the imponderable values of the Corporation is to be found in the forging by it of a link between scientists and industrialists, types of men who often find a difficulty in understanding one another, with the unfortunate consequence that potentially valuable discoveries may fail to find industrial backing. It was, of course, an appreciation of the difficulty which led to the creation of the Corporation. In fact the Corporation really does seem to be doing the job it was set up to do.

The Engineer—100 Years Ago (DECEMBER 23, 1859)

"COMFORT IN RAILWAY CARRIAGES"

"Whilst the disciples of meteorological science are ransacking the records of half-a-century in search of a parallel to the recent severe cold, we hope the railway managers have not forgotten that the toes of long-journeying passengers are painfully sensitive to low temperatures. The relationship, indeed, between the toes and the weather is often much more intimate than is supposed. We know individuals who will consult a favourite corn in preference to an aneroid barometer, and who can translate the titillations of the former with more certainty than the indications of the latter. As a dry-bulb thermometer, also, the little toe will register the freezing-point with the approximate accuracy and all the disagreeable permanence of a chilblain. Really, the hot-water pans, or *chaufferettes*, so universally in use on the continental railways, should be adopted on every line in the Kingdom. In the American railway carriages, the passengers are made to face diabolical stoves—not unfrequently red-hot, and the consequence is that the upper stratum of air, in a carriage seating sixty persons, is—speaking mildly—overheated, whilst the lower portion of the interior of the vehicle is at a temperature corresponding to the formation of chilblains."

Recent Production Developments in the Soviet Union

No. II (*Concluded from Page 813, December 18*)

The Sir Alfred Herbert paper for 1959 was presented to the Institution of Production Engineers on Thursday, December 10, by Dr. D. F. Galloway, director of the Production Engineering Research Association of Great Britain. In his paper, Dr. Galloway gave some impressions obtained during a five-week tour of the Soviet Union, Poland and Czechoslovakia by a delegation from P.E.R.A. The observations were mainly concerned with production engineering research and development, general industrial development, and the engineering and scientific information services in the countries visited. Dr. Galloway's paper is of particular interest to all engineers concerned with research and development, and abstracts from it are given below.

Production Research and Development in Russian Factories

In addition to the intensive research into new and improved production techniques and equipment which is being carried out at central research stations such as ENIMS and TSNITMASH, many of the most progressive Russian factories are also conducting investigations into existing techniques and equipment, frequently in conjunction with a research institute. For example, following reports from the Gorky factory and other plants that high feed rates had given very satisfactory results in gear hobbing operations with high-speed steel hobs, investigations were carried out by VNII (The Metal Cutting Research Institute) at three different factories in order to determine the effects of high feed rates on hob life and gear accuracy.

Output in some Russian factories has been substantially increased by rationalising machining operations performed on similar groups of components. For example, group machining operations at the Red Proletariat Factory increased the yearly output of various types of forked components from 12,000 to 60,000. Group machining in general increased output two to three times, and machining costs were substantially reduced. Components which are being selected for group machining are first sorted according to their size, shape, material, design characteristics, and the range of machining processes involved in their manufacture. Machining operations are then carried out either by simultaneously machining a complete group of components without major resetting of tools or machines, or by machining different parts of the group after minor resetting.

Automation Research and Development in Russia

The activities of ENIMS and a number of other Russian research organisations have been reorientated in the last few years to bring them more closely into line with the growing needs of industry for assistance in automating production. According to Mr. Kruschev, measures for the development and introduction of new machinery and technology are to be given all priority "financially, materially and technically." The chairman of the State Committee for Automation and Machine Building has announced that the machine building technological institutes are to be reorganised and a number of new institutes set up to expedite the growth of automation in Russian industry.

About 1300 new automatic lines will be brought into operation between 1959 and 1965, and the number of specialised and multi-headed machine tools is to be doubled in this period. With the whole economy geared to the widest possible use of automation, Russian industry is rapidly becoming one of the most automated in the world. The main emphasis is being placed on the creation of fully automated processes, workshops, and factories rather than on the automation of individual production operations. Because of the acute shortage of labour which Russian industry is now experiencing, all labour displaced by automation is quickly absorbed in the same factory or a neighbouring plant.

ENIMS has made an especially significant contribution to the development of automation in Russia, and designed its first automatic line incorporating unit machines in 1935. The first Soviet automatic lines for machining tractor cylinder heads was constructed at the experimental factory at the beginning of 1946, and an automatic factory for the production of automobile pistons was built in 1950, in conjunction with various machine tool plants. Raw material is fed in at one end of the piston line, and matched sets of cast, machined, inspected greased and packed pistons emerge at the other end. Other completely automatic lines have also been built for machining rotor shafts for electrical motors, gears and splined shafts for machine tools. Compared with conventional equipment, the original rotor shaft line more than doubled output to 200,000 shafts per annum, increased output per man tenfold, and cut production costs by more than half ; an improved version of this line has now been built. The gear line produces about 10,000 gears a month in ten sizes ranging from about 3in to 12½in in diameter. The operation of the whole line is controlled from a single panel.

An automatic line designed and developed by ENIMS for machining thirteen different sizes of splined shafts produces 260,000 shafts a year when operating for two shifts a day. The automatic line has reduced the number of operators needed for the production of shafts from fourteen to three, and the machining cost from 4·18 roubles per shaft to 3·33 roubles.

Czechoslovak Production Research

The close co-operation which exists between Russia, Czechoslovakia, Poland, China, and other Socialist countries in all fields of science and technology has immeasurably raised the industrial potential of the whole group. Multi-national scientific and technical commissions meet regularly to promote the most effective interchanges of knowledge and experience, and to rationalise the productive resources of the Soviet bloc. Czechoslovakia's rapid post-war industrial progress, which is a factor of considerable importance in the advance of the bloc as a whole, has been due in part to the effective application of the improved production techniques and equipment developed at Czechoslovak production research centres such as the Machine Tool and Metal Cutting Institute at Prague and the Metal Forming Institute at Brno.

Machine Tool and Metal Cutting Research Institute

The Institute, generally known as VUOSO, obtains almost all of its income of about £700,000 per annum from the group of twenty-five firms which have been merged under the title "Czechoslovak United Machine Tool Factories," generally known as "TOS." The technical and commercial activities of the firms have been rationalised on a national scale, and only one type of machine tool is usually produced in a particular factory. Common design standards are adopted by different factories wherever possible, and efforts are made to utilise fully all the technical and manufacturing resources of the industry as a whole.

The contribution of the Government as such to VUOSO represents only about 10 per cent of its income, the balance of 90 per cent being received from the machine tool factories in the form of annual donations, or as payment for sponsored research. The Institute has a total staff of over 300, about 150 of whom are employed in the machine tool research division ; and about fifty in the metal cutting division. A third division investigates high frequency heating techniques and equipment. A group of about twenty engineers advises industry on machine tools and metal cutting techniques, and frequently co-operates with the Czech Institutes engaged wholly on modernising existing works layouts and planning new factories.

Principal objectives of VUOSO machine tool research are to determine the fundamentals of machine tool design and construction, to carry out comprehensive tests on prototypes, to modify designs in accordance with the results of the tests, to develop electronic devices, servo-mechanisms, &c., in machine tools, and to solve fundamental problems of vibration, friction, lubrication, &c.

An interesting example of the work of VUOSO is the development of magnetic scales by Ing. Karel Stepanek under the direction of Dr. Jiri Tlusty. Ing. Stepanek has been awarded a Czechoslovak State Prize for this work.

Magnetic scales have a wide range of application in checking the accuracy of gears and gear trains, determining errors in gear manufacturing machines, angular measurement, and in the production of dividing standards. Other possible uses include linear magnetic scales for measuring lengths of travel, the measurement of torsional deformation and vibration, &c. Magnetic scales have already played an important part in improving accuracy in the manufacture of Czech gear manufacturing machines, and in the production of high-precision dividing equipment.

A magnetic scale consists of a circular metal disc carrying on its periphery a layer of iron oxide or a special alloy of copper, nickel and iron. A sinusoidal magnetic field consisting of an integral number of waves is recorded on the periphery of the disc. Each wave corresponds to the distance between a pair of gauge lines on an engraved scale, but as the magnetic wave is continuous, any point on it can be easily defined and thus continuous measurement is possible.

When a worm gear transmission, for

example, is being inspected, two discs are mounted on the axes of the worm and wheel. A sinusoidal magnetic record on the periphery of one disc is transferred to the other, and by measuring the changes in phase between the frequencies picked up from both discs after filtering out certain errors, the inaccuracies in the transmission can be determined with an accuracy greater than 0·5 second of arc.

The main advantages claimed for the magnetic scale are its high precision, reliability and versatility. The accuracy of the mechanical equipment employed does not affect the accuracy of measurement, and the influence of temperature, and other factors which may change with time are eradicated. Measurements can be made under heavy duty operating conditions, and gear ratios of up to 1 : 1000 can be checked with an accuracy exceeding 0·5 second of arc. Measurement is continuous and takes only the time needed for one revolution of the slowest member of the gear train ; the accuracy of a machine tool gear train may thus be checked in about five minutes. Portable magnetic scale equipment which can be used directly on machine tools has also been developed.

Particularly interesting theoretical and practical studies of " stick-slip " have been made at VUOSO where investigations have led to useful practical results. After numerous experiments, polar additives were found which greatly improved the static characteristics of sliding systems at low speeds. Special oils have been used to reduce or eliminate " stick-slip " in the carriages of lathes, headstocks of cylindrical and centreless grinding machines, columns, and tables of horizontal boring machines, tables of hob grinding machines, &c.

There has been a considerable concentration of effort on the solution of vibration problems at VUOSO, and valuable contributions have been made to the design of dynamically satisfactory structures. Extensive research has also been carried out into the modes of vibration of various types of machine, and data obtained from these experiments have been used to determine, by graphical methods of calculation, the limiting conditions for stable machining. The calculations are based on a relatively simple theory of vibration which assumes that changes in the magnitude of the cutting force are proportional to changes in chip thickness.

A machinability calculator and surface finish measuring equipment have been developed in the VUOSO metal cutting laboratory. An exhaustive analysis has also been made of surface finish requirements for different duties in various industries, and the Institute's recommendations have been incorporated in a standard.

An operational research into carbide tools is being carried out at one Czech factory to determine whether the five standard grades of carbide in use in Czechoslovakia can be reduced to three, and also to increase the number of grinds per tool. It is considered that fifteen to twenty grinds per tool should be obtained, whereas the present average for the whole of the Czech metal working industry is about six to seven grinds per tool. This is considered to be economically more significant than reducing wear, as present practice in this respect is satisfactory. VUOSO's engineers are recording all information but are not significantly influencing such factors as tool deflection, grinding, &c. In order to eliminate operator bias in the experiments, incorrectly marked tools are being issued to operators, whose opinions about a particular grade of tool, country of origin, method of grinding, &c., might otherwise influence the results.

Metal Forming Research Institute

The Institute employs about 150 people and has been in existence for about six years. About 70 per cent of the Institute's income is received from the Ministry of Heavy Machinery, and about 30 per cent is received from industry in payment for sponsored research.

A technique has been developed by the Institute for producing short flute reamers from high speed steel machined blanks by radially forming the flutes, and the technique is also used for producing fluted lengths of high speed steel which are subsequently twisted to form blanks for twist drills. Drills are also being produced by twisting extruded or rolled high speed steel rod. It was claimed that this method of drill manufacture has reduced the cost of drills by 30 per cent, due primarily to economies in material, and that drill performance had also been improved.

Following investigations into the extrusion of aluminium, 0·1 per cent carbon steel, &c., carried out at the Institute on a 2000-ton hydraulic press, many steel components are now being produced by backward and forward extrusion in Czech industry.

All major press failures and breakdowns which occur in Czech industry are reported to the Institute for thorough investigation, and thus data of considerable technical and financial significance are gradually being accumulated.

Production Engineering Research in Poland

Polish industry has made a remarkable recovery, having regard for the fact that in 1945 whole cities and industries were in ruins, 6,000,000 Poles had died in the course of the war, and most of the people who survived had suffered the physical effects of long privation and incredible hardships.

The industrial recovery has been assisted by a number of production engineering research centres including the Institute of Metal Cutting, the Institute of Organisation in the Engineering Industry and specialist institutes such as welding, foundry work, &c.

One of the research centres visited during the tour was the Institute of Metal Cutting Research which is known as IOS and is at Cracow.

IOS—Institute of Metal Cutting Research

Research into metal cutting techniques, electro-spark machining, metrology, ultrasonic drilling, machine tools, &c., is carried out principally by the Institute of Metal Cutting, generally known as IOS. At present, IOS is financed partly by the State, partly by a fund devoted to the encouragement of technical progress in industry, and partly by sponsored research.

A considerable part of the Institute's metal cutting research has been concentrated on problems of lubricating and cooling tools and workpieces and washing away chips. As a result of many investigations, recommendations have been published for the selection of fluids for different types of machining operation.

Investigations into the properties of Polish and foreign cemented carbides have been carried out for several years, and over fifty different types of ceramic and cermet tip have been produced on a laboratory scale in the Institute in the past five years. Following extensive machining tests, two types of ceramic tip have been selected for large-scale production. One type will be used for roughing both cast iron and steel, and the other for finishing both materials. In machining tests on soft and hard cast irons, the ceramic tips gave better results when cutting the hard irons. The principal constituent of the ceramic material is aluminium oxide, with additions of cobalt and titanium carbide. Ceramic tips are cold pressed and cermets hot pressed.

Rolling techniques have been developed for producing all hand taps, and all machine taps up to $\frac{1}{8}$in diameter, and it is hoped to roll larger sizes of tap as a result of further research which is in progress. It is claimed that considerable sums of money have been saved in Polish industry by rolling taps as compared with machining.

A technique has also been developed for rolling and subsequently hot twisting various sizes of twist drill. Blanks are rolled in lengths up to about $3\frac{1}{2}$ft, and are cut into suitable lengths before being hot pressed into low carbon steel shanks. Drills manufactured by this technique have been in use in Poland for about two years, and it is claimed that it reduces the consumption of high speed steel by about 40 per cent.

A special method described as elastic-tool feed grinding, or constant-pressure grinding, has been developed by IOS. Higher productivity and better tool surface finishes are claimed for this method, and industrial application of the technique has led to considerable financial savings and other advantages. The technique is incorporated in the design of some new types of tool grinder, including a semi-automatic machine for grinding single point tools, some of which are now in production.

The Institute has played an especially important part in the development of electro-spark machining techniques and equipment, and it has developed several prototype electro-erosion machines. It was claimed that the life of a casting die produced by conventional production methods was 5000 components, whereas when produced by electro-erosion it was 7500 components. The time for producing the die was reduced from fifty hours to thirty hours.

Electro-erosion equipment with a power of 4·5kW has also been developed by IOS for cutting off very hard metals using a rotating steel disc about 0·040in thick ; water glass (sodium silicate) is used as the electrolyte. The width of the cut in the workpiece materials is stated to be only 0·063in and the machine is claimed to be very economical for cutting off high alloy steels.

Russian Technical Information Service

The great value of foreign scientific and technical information in promoting rapid industrial development is widely recognised in Russia, and hence foreign literature is translated and digested on a vast scale. For example, at the Centre for Scientific Information, which was established in Moscow, in 1953, a full-time staff of 1800 scientists, translators, editors, &c., is continuously engaged on translating and abstracting reports, papers, and articles published in 10,000 foreign journals printed in eighty-eight countries in sixty-four languages, including Japanese and Chinese. The permanent staff are assisted by 20,000 part-time translators, each of whom is a specialist in some branch of science or technology. More than 2500 journals concerned with

production engineering and related activities are abstracted by the Centre.

The Scientific Information Centre's main activity is gathering, translating and digesting reports of all significant technical developments throughout the world and publication of this information in a thirteen volume abstract journal. The section of the journal covering production engineering research and development is published twice monthly and each issue contains about 4000 abstracts. In addition, the Centre distributes Express Bulletins consisting of extended digests of articles of special significance in the various branches of science and technology.

[The paper then dealt briefly with trade unions, salaries, wages and prize awards, and standards of living.]

Soviet Education

The vast expansion which has taken place in the Russian national economy in the past thirty years would have been impossible without a parallel growth of all forms of education. It has been estimated that even when population differences are taken into account, Russia is now training three times as many engineers as Britain. After general education, which lasts from seven to ten years, specialised training for industry, agriculture, transport, &c., is also organised at three separate levels, namely, practical training for semi-skilled and skilled workers at factory schools, &c.; practical and theoretical courses for semi-professional workers such as technologists at technicums or technical colleges and similar institutions ; and advanced courses for scientists, mathematicians, &c., at the universities and higher technical institutes.

Russian education has a heavy vocational bias even at the university level, and higher technical education has been especially rapidly expanded in recent years. Between 1940 and 1956, the number of Russian engineers holding diplomas increased from 290,000 to 721,000. According to official Russian sources, the total number of specialists with a higher education at work in various branches of the national economy in 1965 will exceed 4,500,000 or 50 per cent greater than in 1958. During this period, the number of engineers to be trained for industry, building, transport, and communications is planned to rise by 90 per cent, with the greatest expansion taking place in the training of engineers for automation, electronics, chemical technology, computer engineering and other new fields of technology.

Conclusion

The Russian economy is clearly expanding at a rate never previously sustained continuously by a major industrial nation. Although Russia still has considerable leeway to make up in many industries, in housing and other aspects of standards of living, the tremendous advances of the past forty years have accustomed all sections of the community to continuous rapid progress. Thus an attitude of mind has been created which allows the momentum of the Russian drive to be maintained indefinitely without undue strain on managers, scientists or workers. Present evidence suggests that the ambitious targets set by the current seven-year plan will be achieved, and hence the claim that by 1970 the Soviet Union will rank first in the world both for physical volume of production and production per head of population should not be ignored.

Production engineering research and development are making a major contribution to the rapid advance of many branches of Russian industry, and widespread recognition of the practical and economical importance of such research has led to demands from managers and engineers in industry for a further expansion of Russia's already massive production research facilities.

Britain, the U.S.A., and other Western countries can only meet the challenge which Russia's tremendously vital industries now present, by providing every assistance and every incentive to their own industries to raise productivity by the continuous improvement of production techniques and equipment. In the widest context, this will demand an extensive reappraisal of the present situation by governments, managements, scientists, engineers, workers and workers' representatives.

Russian progress should be regarded not as a threat but as a challenge, which if met will lead to higher standards of living and greater security than Britain has ever known before.

Some Aspects of Marine Reactor Safety

On Tuesday, December 15, a paper entitled " Some Aspects of Marine Reactor Safety " was read by K. Maddocks, B.Sc.(Tech.), at The Memorial Building of the Institute of Marine Engineers on behalf of the Joint Panel on Nuclear Marine Propulsion. In the paper the engineering aspects of shielding, containment and fuel element design are covered by analysis of the problems and suggestions for methods of calculation. Hazards peculiar to commercial marine installations are considered and safety recommendations made. Finally, a detailed survey is made of accidents to large ships over the last decade, from which are deduced pointers regarding ship structure and equipment applicable to nuclear-powered ships. We give below abstracts from the paper.

THE many studies directed towards the selection of a reactor system suitable for commercial marine propulsion fall into two distinct fields of optimisation, safety and economics ; the conclusions may well conflict. It is the object of this paper to emphasise the paramount importance of the former in examining the engineering problems which influence design.

The American passenger-cargo vessel " Savannah " will be completed in 1960 and presumably she will be the first nuclear ship for which berthing permission will be requested in this country. This points to the urgency of the considerations now being given to the safety of such a ship.

The principal hazard faced in any nuclear power plant is the biological effect of ionising radiation. Damage to tissue can be caused by both external irradiation of the body and either ingestion of, or contact with, active particulate matter. Hence, both shielding and containment are treated in the paper. The paper assumes that interest will centre on the pressurised water reactor (PWR) and its variants, the boiling water reactor (BWR) and the organic moderated and cooled reactor (OMR). The three reactors each power a propulsion plant capable of producing about 20,000 s.h.p.

The Shielding of Marine Reactors

The shield configuration promising optimum effectiveness, for the reactor systems of interest, consists of several components. The primary section of the shield envelops the reactor vessel extending outwards from the reactor core boundary. It is intended to decrease or attenuate the neutron and gamma radiation from the core under power, to a level which is not harmful to the components outside nor sufficient to induce activation of materials in the area. The primary shield must also be adequate to attenuate core radiation under shut-down conditions to allow the personnel access required. It has been found that an attenuation factor of about 10^{-6} for both neutrons and gamma rays is the order required.

The secondary shield envelops the active primary circuit and reduces radiation intensity to allowable biological levels in the surrounding compartments and areas outside the ship structure. It can therefore exploit the shielding effect of distance (the approximate square law).

Having accepted the concept of primary and secondary shielding, the next stage is to establish allowable radiation levels in all compartments throughout the ship and other areas adjacent to the reactor, both for power operation and under shut-down conditions. The immediate result of this survey is to establish areas of unrestricted access and those of controlled access. The former aims at providing the same ship routine facilities as apply to conventional ships. To achieve this it is suggested that a total integrated dose of 0·5 rem per year should not be exceeded.

The principal objective is to shield fast neutron and gamma radiations. During the fission process, neutrons varying in energy up to about 15 MeV are emitted and the fast neutrons must be degraded in energy by scattering collisions before capture is possible. Thus the reactor as a neutron source is only effective during operation.

Sources of gamma radiation fall into two main classes. Gamma rays resulting from neutron capture in the coolant or structural material are produced only during reactor operation, whereas gammas emanating from the decay of fission products and activated nuclei, in both coolant and structural material, are effective both during operation and for long periods following shut-down.

Shielding Materials.—The most efficient fast neutron shields are those containing large amounts of hydrogen and the obvious choice is water ; fuel oil may be a convenient alternative, or polythene for awkward locations. Conversely, the heavy elements show marked advantages in shielding gamma radiation where the mechanism is one of energy absorption. Thus the shield having the smallest mass per unit area will rely on water or some other hydrogenous medium for neutron attenuation and a heavy element (such as lead or steel) for gamma ray attenuation. This separation of gamma and neutron attenuation function allows the heavy material to be located nearer the core and thereby effects a weight saving. Moreover, for the systems of interest the reactor design will include provision of a thickness

of liquid reflector, one or more steel thermal shields separated by coolant gaps, and the pressure vessel. This laminate array is a ready made first section of the primary shield and the use of similar materials for the region outside the pressure vessel will simplify the design. A good example is the water reactor which would have a total steel thickness of, say, 9in (thermal shields and pressure vessel) plus a total water thickness between core and pressure vessel of, say, 9in to 12in.

Allowing for the additional steel required for the reactor supporting structure, the primary shield probably could be completed by a surrounding tank containing about 3ft thickness of water and possibly an outer layer of lead.

There is no method of calculating the shield thickness which is both simple and accurate. Nevertheless, an approximate design procedure is necessary to co-ordinate the effort with preliminary machinery layout and weight estimates. One simplified method is given.* This paper quotes the following table :

TABLE I—*Approximate Shielding Material Thickness in Inches to Attenuate Given Radiation by a Factor of* 10

Principal use	Material	Core gammas during operation (7MeV)	Fast neutron	Core decay gammas (2·5 MeV)
Fast neutron shield	Water	38	9	24
	Polythene ...	38	8	24
	Fuel oil... ...	48	9	30
Gamma shield	Iron (or steel)	4·6	5·5*	3·6
	Lead	2	8*	2·1
Combined neutron and gamma shield	Ordinary concrete	17·5	10	12
	Barytes concrete	9·4	7·25	7·5
	Magnetite concrete	10	7·5	7·5
	Ferrophosphorous concrete	7·1	5·75	5·5

* If backed by 12in to 18in of water, polythene, &c., or when used in laminations with water.

The crux of the primary shield design is the calculation of the thermal neutron flux pattern through the array. This establishes what proportion, if any, of the fission neutrons escape from the shield and also the equally important gamma production by neutron capture which governs the induced nuclear heating in the shield.

Coolant Activity.—The primary coolant circuit may be activated in two distinct ways, the relative importance being different for the water and organic systems.

For a water system, the intrinsic or induced activity following passage through a region of high neutron flux is caused by two fast neutron/proton reactions.

(*a*) $O^{16}N^{16}$ giving a 6·13 MeV gamma with 7·4 seconds half life.

(*b*) $O^{17}N^{17}$ giving a 1·0 MeV neutron with 4·1 seconds half life.

The abundance of the two target isotopes in water is 99·8 per cent and 0·039 per cent for O^{16} and O^{17} respectively ; hence gamma production is the most serious problem, dose rates of the order of 50 r per hour on the inner surface of primary circuit pipework being typical. The degree of activation built up in the water for such short lived isotopes will reach an equilibrium value which is a function of both the neutron flux level through which the reactor coolant passes and also the ratio of the core and primary circuit volumes (irradiation time to decay time ratio). With the organic reactor there should be no detectable intrinsic activity if the inclusions of Na, Mg and Cl are kept to trace values.

The primary coolant may also carry active sources consisting of either metal nuclides corroded from or fed into the system, or fission products which may escape from damaged fuel elements. The water reactors are far more susceptible to corrosion than the organic reactor. Coolant additives must also be carefully checked, e.g. the use of ammonium pentaborate as a control absorber leads to the formation of Na^{24} under irradiation. All the activated impurities have relatively long half-lives, thus becoming important under shut-down conditions. Additional shielding requirements resulting from the anticipated release of fission products must be assessed in considering fuel element design. In this respect the organic reactor coolant may have very low intrinsic activity and corrosion product activity but the elimination of coolant shielding should not necessarily follow without regard to possible fuel element failure.

Secondary Shielding.—Considering first the fast neutron shielding, the sources clearly emanate from the reactor and the main difficulty is in establishing possible streaming paths radially through the primary shield. For the three reactors considered here the appreciable quantity of coolant above the core and the accumulation of structural material in the pressure vessel closure and control gear considerably assists attenuation of radiation vertically upwards. The degree of attenuation of radiation vertically downwards is usually determined from possible induced activity of the ship structure rather than biological dose rate.

The procedure for calculation of gamma shielding is similar but slightly more complex. As an illustration, referring specifically to water reactors, one method may be of interest.

(1) A number of dose points are selected over the surface of the secondary shield, the procedure being to calculate the dose rate at each point for two arbitrary iron shield thicknesses, say, 4in and 8in.

(2) The reactor vessel is first assumed to be a negligible source compared with the remainder of the primary circuit and this circuit is approximated by sources of convenient geometrical configuration.

(3) The distance from each source to each dose point, the angle subtended by each source at each dose point, also the thickness of structural iron along each line of sight, is tabulated.

(4) The dose rate at each point from each source is computed and two corrections made : first, a geometry correction to allow for the simplified source configuration used and second for the accuracy of build-up data available.

(5) Two dose rates are found for each point, each applicable to either the 4in or 8in iron shield assumed. Representative points are found by plotting the two dose rates on a logarithmic scale to a base of shield thickness on a linear scale. The intersection of the connecting line between the two points with a line representing the tolerable dose rate gives the total thickness of iron shield required. Deducting from this the thickness of structural shield applicable gives the net iron thickness required and this is then converted to an equivalent lead thickness.

(6) A check is now made to ascertain the validity of neglecting the reactor vessel as gamma source. Additional lead shielding may be required round the primary shield to justify this assumption.

Once the mechanical design concept is established, the shield designer's task can be defined. From the irradiation history of the fuel an assessment of the gamma source strength can be made. A time-and-motion study affecting personnel engaged will determine allowable dose rates. In this respect it is safe to assume that refuelling will only be necessary at annual or even biennial intervals. The establishment of a routine drill would be appreciably assisted by the use of a full scale mock-up. Thus, dose rates of several hundred millirŏntgens per hour are tolerable within the area providing that exposure is of short duration. It follows that the mechanical design should be as simple as possible, and ample access should be provided. The total time for complete refuelling of any of the reactors of interest is expected to be between three and four weeks with shift working. It is doubtful whether even partial refuelling, say, replacement of 10 per cent of the core, could be accomplished in much less than two weeks. It is unlikely that the economics of ship operation will allow any appreciable cooling time before refuelling. A useful approximation of source strength from the fission products, one day after long operation, is one curie per watt of reactor power. Due to uneven burn-up, the centre element activity may be twice or three times this average. Accurate shielding calculation depends on the establishment of the gamma spectrum which can range from 0–2·5 MeV.

Opening up the reactor also involves shielding against gammas from the induced activity of the pressure vessel and core structure.

CONTAINMENT

Million curie quantities of radioactivity may well be contained in the fuel elements of a marine nuclear power reactor, and the possible consequences of a large scale release of this activity in the event of an accident in a heavily populated port area would be disastrous. The overall engineering problem posed by the prevention of the escape of any significant fraction of this activity is usually referred to as " containment."

The two main potentially dangerous conditions are those caused by an excessive power surge or temperature transient in the reactor, and fire.

Fire hazards may well pose particularly acute problems in marine plants. It is debatable whether fission products would escape in such an event ; much would depend on the design of the reactor and its containment. However, it must be borne in mind that a " cold " reactor, the condition most likely during overhaul, is a condition of acute potential danger due to the necessity of holding down excess reactivity.

Suggested Design Procedure.—A sequential barrier arrangement between fuel and atmosphere should be designed for maximum overall integrity. This could comprise :

(i) The use of a ceramic fuel which acts to contain partially the fission products within its own matrix.

(ii) The enclosure of each fuel rod in a sealed metal can which is resistant to corrosion and erosion and also withstands the external and internal pressures under all operating conditions.

(iii) A main coolant (primary) system to withstand all normal operating conditions and any externally applied shock loading requirements.

(iv) A containment vessel which completely envelops the primary circuit, thereby providing the final barrier against release of activity during the worst conceivable accident condition.

There appear to be three approaches to the provision of item (iv): (*a*) A containment

* Vann, H. E., *et. al.*, 1958, " Shielding Aspects of Nuclear Power Plants for Marine Propulsion," *Trans. S.N.A.M.E.*, Vol. 66, page 491.

vessel of cylindrical or spherical form, hermetically sealed, which is supported by the ship structure and capable of withstanding the internal pressure accumulating from the release of the contents of the primary circuit plus some fraction of the secondary (steam). This is known as unit containment and appears to be the most acceptable approach at present. (*b*) Structural strengthening of the compartment which houses the reactor plant, to withstand a similar internal pressure. The main objection to this approach is the limiting pressure to which a flat bulkhead can be subjected without excessive frame reinforcement. This is considered to be 25 lb per square inch to maintain leak tightness. (*c*) A combination of the two methods above leads to the so-called "controlled containment," where the unit containment vessel is minimised in weight by using a design pressure below a conceivable maximum.

Calculation of Internal Pressure in the Containment Vessel.—The most difficult part of this estimate is in postulating the maximum credible accident which can affect the release of heat energy to the containment vessel. A heat balance is made on the basis of conservation of the internal energy of the fluids affected.

The following assumptions are offered as suggestions :

(1) Any major fracture of the primary circuit can result in the release to the containment space of the total content of the primary circuit.

(2) For a system with a two-loop secondary circuit, it should be assumed that the steam from one heat exchanger only is released to the containment space. For a four-loop secondary circuit the steam from one or two heat exchangers is assumed released.

(3) Where the primary shield includes water, which could amount to about 100 tons, and normally cooled to maintain an operating temperature of about 120 deg. Fah., it may be considered as a heat sink.

(4) The cooling effect of the containment shell, steel structure and equipment within the containment space is neglected. This is a safety factor justified by the assumed instantaneous (adiabatic) release of steam and high temperature water.

Once the above assumptions have been accepted the sum of the internal heat content of each component under normal running conditions is derived.

The problem is then to determine an equilibrium temperature following flash-off of steam and water, and mixture with the air. Then the partial pressures of the resultant steam and air are determined, the partial pressure of the steam in air corresponding to its normal partial pressure at the equilibrium temperature. The sum of these partial pressures (air + steam) gives the equivalent "working" pressure of the containment vessel. The plate thickness of the shell can be determined by the application of a conventional boiler design code.

Typical values of the containment internal pressures for the three systems of interest are :

Reactor	Primary system pressure, lb per square inch	Maximum internal pressure, lb per square inch
PWR	2000	170
BWR	1000	120
OMR	100	60

Detailed calculation shows that the significant contribution to the input heat, for both water reactors, is the contents of the primary circuit, whereas for the organic reactor the secondary steam release governs the calculation.

An adequate unit containment must also include provision for the following functions :

(*a*) Containment strength must be adequate to support the secondary shielding of lead and polythene. The structural strength must also include its integration in carrying the static weight of the reactor and primary shield to the ship structure. The design must be checked for any shock loading conditions imposed and possible missile damage.

(*b*) High temperature differentials may occur under emergency conditions across the containment shell. A major disaster such as the melt-out of a reactor core which could conceivably penetrate the pressure vessel can be localised by release of the primary shield water and steam blanket formation within the containment vessel.

(*c*) The hermetic sealing of the containment must include the provision of air locks if the integrity is to be maintained during maintenance or refuelling.

(*d*) The internal surface must be as smooth as possible to minimise decontamination work.

There are three feasible forms of containment vessel, a sphere, a vertical cylinder with dished dome, and a horizontal cylinder with dished ends.

Fuel Element Integrity

The most important component in reactor design is the fuel element. Its integrity, in containing the fission products, is a vital factor in the safe operation of the reactor.

[The author considers the design in detail and deals with such items as : selection of fuel ; selection of canning material ; pellet size ; heat transfer calculations to determine maximum temperatures of can and the oxide fuel ; radial flux distribution and gagging ; modified flux distribution due to control rods ; fuel centre temperature ; and mechanical design.]

Hazards Peculiar to Marine Installations

Mounting a reactor on a platform subjected to complex ship motion produces many problems. North Atlantic winter conditions could produce a combined pitch, roll and heave peak acceleration for a low location, amidships of $0{\cdot}5\,g$. This acceleration is cyclic and is therefore of importance when considering the effect it may have on the stability of the reactor, particularly in the case of the BWR. It is probable, however, that random, non-cyclic, accelerations, having peak values possibly up to $1\,g$, can occur under extreme conditions.

To cover for shock effects it is believed to be prudent to introduce into the design shock requirements of about $5\,g$ vertical and $3\,g$ athwartships. In addition, to cover collisions, a figure of $1\,g$ would apply. Reactor instrumentation is particularly sensitive to these requirements and such items as flux detectors with the associated electronic equipment, to withstand these acceleration loads are not commercially available in this country. Clearly also under these conditions, the control rod drives must incorporate some form of locking mechanism to prevent disturbance of operational settings.

The consequences of fire are always a major consideration. The main concern is to prevent paralysis of the external controls and a gaseous (probably CO_2) fire extinguisher system appears more attractive than water, foam or steam systems for the areas containing control equipment. It is not conceivable that any combustion could be supported within the core of a liquid cooled reactor. Another safeguard is the use of fuel in the form of an oxide of uranium which is not combustible even in air. The inherent hazard in the use of an inflammable hydrocarbon in the reactor system is peculiar to the organic moderated reactor and will require a controlled nitrogen-rich atmosphere within the containment.

The possible stranding of a nuclear propelled vessel raises a special problem of the disposal of the heat generated in the core following shut-down. This decay heat generation will decrease approximately exponentially for all reactors and the quantitative value on a time base can be determined for each system : e.g. U_{235} after long irradiation will produce decay heat approximately as described by :

$R/R_s = 0{\cdot}07\,t^{-0{\cdot}2}$ for $t > 1$ where
R_s = Steady power level prior to shut-down.
R = Power level at time t second after shut-down.

Thus one second after shut-down 7 per cent of the full power heat output must be dissipated ; five hours after shut-down nearly 1 per cent of the full power heat output is still being generated.

In designing a system to remove this heat sufficiently to prevent fuel element burn-out, in the event of a nuclear ship running aground, the following allowances should be made :

(*a*) Isolation of the ship from the sea as a heat sink may well be precluded by the vessel's draught and in any event will not be instantaneous. Any such isolation will be cyclic according to tidal action and therefore a header tank type of heat accumulator could be replenished twice daily. (*b*) A natural convection circulation system offers freedom from power demands but should not be required to meet the peak demand immediately following stranding. By definition the decay heat available during this period is maximum and could be used to generate the necessary power for circulation. (*c*) Air may be used as a heat sink with an extended surface grill exchanger. This type could be used for a system with relatively low heat rating and also for longer term protection following, say, a few days' use of the header type cooling system referred to in (*a*). (*d*) Any stranded ship cannot be expected to remain on an even keel and the maximum angle of heel to be expected is a matter of design policy. It is, however, an important criterion, particularly for a natural convection system which depends on the vertical thermal head available. Any such heat exchangers must therefore be duplicated and offset each side of the centre line to accommodate the list specified.

The results of foundering should be considered under two separate headings, dependent on the depth of submergence, both of which assume that the reactor can be made subcritical before sinking, i.e. the emergency control arrangements must ensure that any submergence would not cause a power surge of magnitude sufficient to disrupt the reactor.

Foundering in shallow water is assumed in this paper to be submergence to a maximum depth of 40 fathoms. This is the more serious case as it includes tidal estuaries and other coastal waters where the release of fission products could contaminate the fisheries and beaches. There is no doubt that a submerged nuclear ship could be worked on by divers surrounded by the shielding medium of water. It would appear reasonable to expect that any salvage

operation could be completed within twelve months, thus setting a time limit for wastage. Hydrostatic pressure at these depths will not appreciably exceed 100 lb per square inch, thus the primary circuit should remain intact. With the sea as heat sink there seems little possibility of a core melt-down. However, assuming that the primary circuit is breached, then the condition arises of replacement of moderator and coolant by sea water. There may well be a number of fuel elements whose cans were damaged previous to, or simultaneously with, the sinking. For the remainder, however, the problem amounts to checking the corrosion rate and can thickness against the salvage time.

It would, however, be expected that the gaseous products would immediately escape from any breach of the can. Krypton 85 (10·4 year), Xenon 135 (9·2 hour) and possibly Iodine 135 (6·7 hour), although the latter is liquid at sea temperature, may be expected to form the most serious immediate release. Entry of sea water within the can allows leaching of the metallic products, such as Cæsium 137 (30 year) and Strontium 90 (28 year). In considering the significance of the half-lives shown in brackets, it should be remembered that, in general, the intensity of decay radiation is inversely proportional to the half-life of the isotope.

Foundering in deep oceanic waters is not considered to involve dangers additional to the loss of the vessel.

The free and unrestricted entry of a nuclear powered vessel into ports and harbours throughout the world must await the establishment of confidence which can only follow several years of successful nuclear ship operation. It is one of the main objects of the "Savannah" project to demonstrate safe operation and thereby overcome any natural reticence in the authorisation of berthing facilities. Even if international agreement is not immediately forthcoming, the development of a nuclear powered tanker is not seriously affected.

The availability of propulsion power under all foreseeable conditions is most essential. The two most popular methods of solution are either to provide sufficient reactivity to override the poisoning phenomena or to provide a dump condenser which can accommodate full power steam output and therefore allow an independent rate of reducing reactor power.

The necessity for the provision of any elaborate gear to deal with the replacement of damaged elements at sea is undesirable. Any such equipment must be heavily shielded and could be an embarrassing stability consideration if located above the reactor.

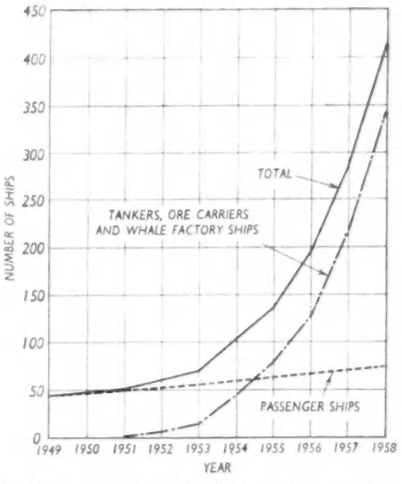
Reliability of the instrumentation and the control mechanisms is another problem aggravated by marine conditions such as a salt-laden atmosphere, and when attached to a structure subject to shock loads and ship motion.

As a final note in discussing the availability of propulsion power, some mention must be made of an independent source of power with which it would appear prudent to equip the first nuclear-powered ships. The primary purpose of this power source is for the emergency condition caused by failure of reactor power at sea. This is the so-called "take-you-home" plant which would include an auxiliary system to transmit a reduced power to the propeller shaft.

Shipping Casualties

The propulsion power range of interest has been defined as 20,000 s.h.p and above. Assuming a maximum service speed of 20 knots, then the minimum displacement of ships within this power range would be 20,000 tons gross.

To place casualty statistics within the context of world shipping figures, reference is made to the diagram, prepared from information supplied by Lloyd's Register



World total of ships of 20,000 tons gross and above

of Shipping. From this plot it can be seen that the growth of world tonnage is divided into two types, passenger ships carrying a relatively small amount of general or refrigerated cargo, and the remainder, which almost entirely consists of oil tankers, but which also includes ore carriers and whale factory ships.

During the period under review, there were three passenger ships written off as total losses, while the cumulative service time amounted to 584 ship years. It could be argued therefore that the chances of survival of a passenger ship on an annual basis is about 200 to 1 but the small number of losses recorded is statistically unsound. The moral evident from the total loss by fire while in port of two of the three passenger ships must be underlined.

There are only two tankers listed as total losses, both by explosion and fire. During the eight years considered the cumulative tanker service time amounted to 828 ship years. Here again the loss of two ships is insufficient evidence on which to base statistical probability.

The information on partial losses is summarised in Table II.

Table II

Type of accident	Passenger ships 1949 : 1958	Tankers, &c. 1951 : 1958
Grounding	11 (4)	8 (7)
Collision	3 (3)	11 (9)
Fire	4 (3)	1 (1)
Heavy weather	1 (0)	2 (2)
Machinery defect.	1 (0)	4 (0)

The figures in parentheses indicate an estimate of the maximum possible number of accidents which could have affected the reactor compartment of a nuclear powered ship. These total twenty-nine for both classes of ship, of which twenty-one occurred either in port or in coastal waters.

A reasonable agreement in casualty rates is obtained in considering possible district hazards which could be caused by the two types of ship if nuclear powered.

The maximum number of casualties, including total losses, which occurred either in port or in a confined waterway, and which could have affected the reactor compartment, is: (*a*) For passenger ships, a total of twelve accidents during a cumulative service time of 584 ship years. (*b*) For tankers, a total of twenty accidents during a cumulative service time of 828 ship years.

These figures indicate a possible casualty about every forty-five ship years. However, the corollary, that when the world total of nuclear powered ships reaches forty-five, an annual potential district hazard may occur unless special structural protection is provided, points to the urgency of these provisions.

The accident statistics indicate that three main ship design factors influence safety. In the event of fire the location of a containment vessel within a reactor compartment provides a surrounding cofferdam which could be flooded with CO_2 in an emergency. A water sprinkler system on to the containment shell would serve the same purpose and also assist the reduction in internal pressure following a sudden heat release to the containment vessel.

Complete flooding with water of the surrounding reactor compartment may be slower in effect, but it could provide both cooling and additional shielding in the event of a release of activity to the containment vessel. These arrangements are primarily designed to prevent fire damage to the reactor installation while the ship is operational. Duplication of the systems is desirable, particularly in tankers where the casualty list shows that fire often follows a collision.

The returns also show the prevalence of major fires while a vessel is under repair. It is therefore a matter of absolute necessity that the strictest supervision be effected.

The novel feature of nuclear ship structure is in the location and protection of the reactor compartment. The perpendicular impact of the "Stockholm" at 20 knots, in sinking the "Andrea Doria," resulted in a penetration of 15ft into the hull. This is the only collision resulting in a total loss reported over the last decade. Such penetration, although not extensive, could certainly be reduced if a correctly designed, energy absorbing structure forming a collision barrier is provided on either side of the reactor compartment. For containment support, it is suggested that the lateral support against rolling loads should be arranged to eliminate the risk of containment fracture during collision by the use of ties or shearing joints. To maintain the containment integrity even when the bottom plating is damaged, it seems desirable that the containment and reactor weight be borne on an internal raft structure.

Large Strongroom Doors.—Two strongroom doors, claimed to be the largest ever made in Europe, each weighing 33 tons and more than 10ft high, have been made by Chubb and Sons, Lock and Safe Company, Ltd., 175, Tottenham Court Road, London, W.1, for the head office of the Bank of Montreal in Canada. Clad with stainless steel inlaid with bronze but intrinsically of a steel alloy known to afford the most efficient resistance to modern methods and instruments of attack, the new doors will not only protect the bank's vaults but will also provide the centrepiece of the bank decor in the section used by the public. The doors, each 3ft 6in thick and incorporating a solid metal slab 2ft deep will be guarded by four keyless combination locks and a time lock which according to the setting predetermines the exact moment in the normal way at which the combination locks can be operated. In the event of an attempt being made to smash the orthodox system with the use of explosives, hidden re-locking devices start to function automatically.

Improved Underground Trains

London Transport recently placed in service the first of seventy-six new trains being provided to replace practically the whole of the older stock on the Piccadilly Line. These trains have a number of improvements including rubber suspension and panelling in unpainted aluminium alloy, and the seating arrangements have been re-arranged. It is stated that the new trains will be placed in service at a rate of one every two weeks until the middle of 1962.

LAST year London Transport placed a £10,000,000 order for seventy-six trains of an improved design for service on the Piccadilly Line, and the first of these trains, built by the Metropolitan-Cammell Carriage and Wagon Company, Ltd., has now been placed in service following experience with three prototype trains. The new trains, known as the "1959" tube stock, will replace the whole of the rolling stock in use on the Piccadilly Line at present with the exception of fifteen trains of the type first introduced in 1938; the other cars being replaced are up to thirty-six years old.

The new cars incorporate many features first introduced in the "1938" tube stock, but in addition major changes have been made which include the use of rubber for the bogie bolster and axlebox suspension, fluorescent lighting, and the panelling of the cars in unpainted aluminium alloy. This use of aluminium alloy panelling, in addition to giving a reduction in weight, and consequently in energy consumption, also makes possible a saving in paint of some 3 cwt per car with a corresponding saving on subsequent overhauls.

Each of the new Piccadilly Line trains consists of seven cars, the maximum length possible with the size of the stations below ground, and each is made up of two units, one of three and the other of four cars. The units have a driving motor car at each end and can thus operate as three-car or four-car trains during the off-peak periods. A four-car unit consists of a driving motor car, a trailer, a non-driving motor car (i.e. a car with motored axles but no driving position) and a second driving motor car. A three-car unit has two driving motor cars with a trailer car coupled between them. A Wedglock coupler gives fully automatic coupling at both ends of each unit and also completes pneumatic and electrical control connections.

The four-wheel bogie suspension fitted on the new cars is of new design using rubber in compression and shear instead of conventional steel springs. Prototypes of this design, which entered service in 1954, have completed about 200,000 miles. These prototypes were based on experience gained with earlier bogies built and put into service in 1947, and in our issue of November 13, 1953, we gave notes on the experimental bogies. One of the bogies now fitted on the cars can be seen in our illustration; in it the bolster, normally mounted on coil springs, is supported at each end by two cylindrical rubber packs in the form of an inverted "V" and inclined laterally to cater for all forces acting on the bolster. Hydraulic shock absorbers are used to damp out vertical and lateral oscillations. In a re-designed axle suspension each axlebox is located between bonded rubber chevron units housed in a cast steel yoke within which they are free to deflect under the control of the rubber units. The yoke casting, which is bolted to the bogie side frame, has a screw adjustment on one side to compensate for wheel wear. As is the current practice on single motor bogies with London Transport rolling stock the bogie is asymmetric to improve adhesion on the motored wheels. The two axle-hung nose-suspended traction motors on each motor car are mounted on roller suspension bearings on the inner axle of each bogie and drive helical gearing.

Two non-metallic brake blocks are used for each wheel, each block being mounted on a combined brake head and hanger, and being provided with an individual brake cylinder with a built-in automatic slack adjuster. Brake blocks of increased thickness, which are now being fitted to the new cars to reduce maintenance costs, are being introduced wherever possible on London Transport rolling stock. Formerly, a non-metallic insert was used inside a flanged cast iron shell, the flange giving the necessary side guiding. Now brake hanger assemblies have been provided with side guiding plates to eliminate need for the flanged shell, the absence of which greatly facilitates re-blocking.

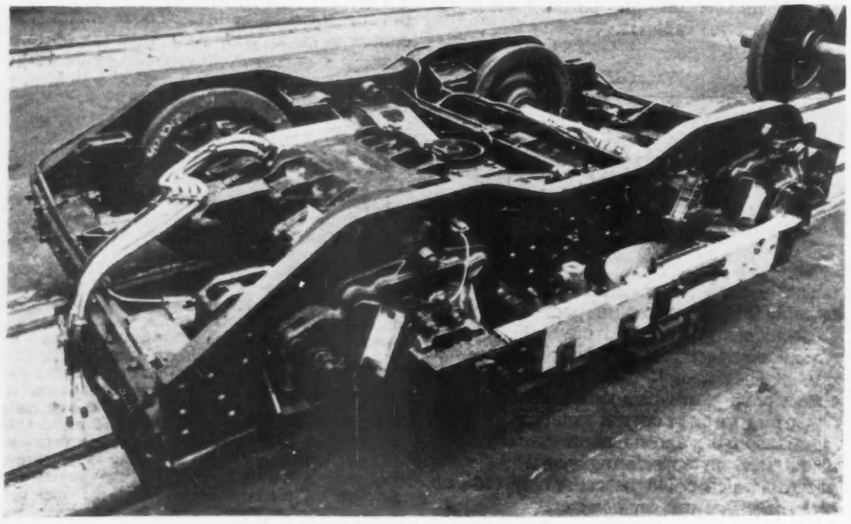
Positive and negative radial-type collector shoes are fitted to all motored bogies. The positive shoes on each side are carried on laminated wooden beams attached to the axleboxes whilst the negative shoe beam is supported from the bogie frame; compensation for height and load variations is provided by the fitting of a cross shaft carrying a compensating lever at each end which rests on an adjustable bracket attached to the positive beam. Provision has been made for isolating all shoes on each bogie from the current rails from inside the car by operating a handle which can be inserted in a socket attached to the cross shaft.

The general car body design is similar to earlier tube stock built in 1938 with the exception that the body is now sheathed in unpainted light alloy instead of steel. An alteration has been made to the interior layout in that the seating in the centre bay has been re-arranged with four double transverse seats in facing pairs at each side of the gangway instead of the previous arrangement of four double transverse seats arranged with the centre two facing each other and the outer two facing the backs of the centre seats. This new arrangement gives improved access to seats and doorways. Each car has two 4ft 6in double doorways on both sides, and single doors 2ft 3in wide on both sides at both ends.

Equipment

Each motor car is provided with two self-ventilated series-wound traction motors, each having a continuous rating of 80 h.p. at 575V, 116A at a field strength of 66 per cent. Following successful small-scale trials with silicone insulated armatures rewound in the main overhaul works at Acton a number of the new motors will have silicone insulation in order to gain large-scale service experience. The traction control gear fitted is the well-tried electro-pneumatic camshaft equipment developed from a pre-war design. The master controller has three positions—shunt, series, and normal running. The series position of the control equipment is reached through nine steps of resistance, automatically controlled by an accelerating relay. The normal running position is attained through nine further steps of resistance and one step of field shunting, all again under control of the accelerating relay. This position produces the lower speed train characteristic and, if required, the driver, by raising a flag switch, can initiate a further automatic step of field shunting under the control of a field shunt relay, which results in a higher speed train characteristic.

The speed characteristics of this stock have been arranged to conform with existing stock, but provision has been made for improvement at a later date. The motors are designed to run over sections of high traffic density with some degree of field weakening, but the speed characteristics of the train conform with those of a train of existing stock on full field. The motors, therefore, reach the full field position at lower speed than on earlier tube stock; this reduces the energy lost in the resistances, the duration of the maximum demand period at starting, and the size and weight of the starting resistances. With the two running characteristics provided at the first stage of field weakening there is a low maximum speed for use in the central area of London—where the traffic density is at its highest—the second, higher speed, characteristic being used for the outer area where the headway is greater.



Bogie fitted with rubber suspension and having axle-hung, noise-suppressed traction motor

Resignalling on the Southern Region

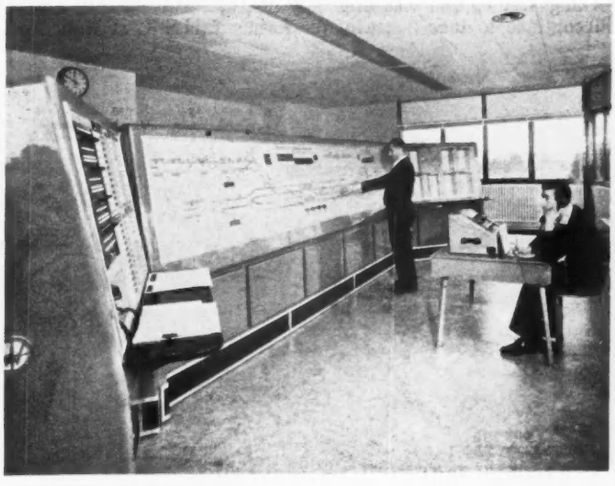
In connection with the electrification of the Kent Coast lines to Margate and Ramsgate, one of the most comprehensive schemes of resignalling yet carried out in the country has been brought into service over 85 miles of heavily-worked main line, and over the Sheerness branch, half of which is single-tracked. One of the new signalboxes, Beckenham Junction, is illustrated alongside.

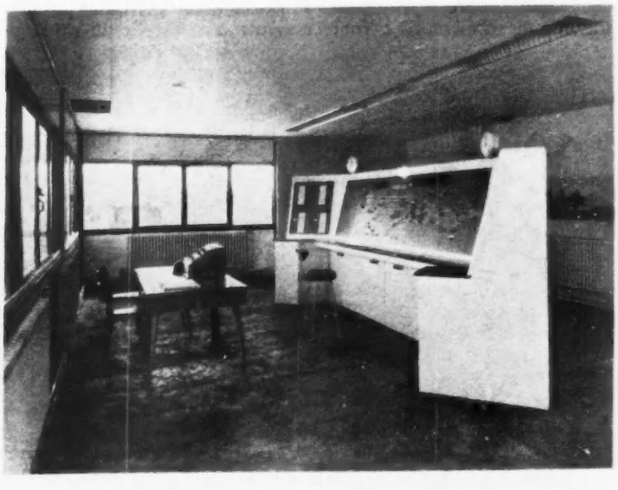
IN Great Britain we have been accustomed to seeing elaborate schemes of power signalling installed at major junctions, large termini and on relatively short sections carrying intense traffic. On the Southern itself, although the electrification to Brighton, in 1932, was accompanied by full colour-light signalling between Coulsdon and the Brighton approaches, not until 1955 was the link between London Bridge, Victoria and Coulsdon completed. On the Kent Coast line, however, the whole route from a point about 2 miles out of Victoria throughout to Ramsgate has been changed from semaphore to colour-light signalling in what has been virtually a single operation. There were, of course, stages in the process of completion, but between March and July, 1959, the whole route, 97 miles in all, had been changed over. The route was already electrified to Gillingham, and the extensions to Ramsgate and Dover were described in our issues of July 31 and August 7, 1959.

Considered as a whole the work is extremely interesting as showing the present-day application, on a large scale, of signalling practice evolved and standardised on the former Southern Railway since the first electrification programme on the former S.E. and C.R. lines in 1925–26. As befitted the largest suburban railway electrification in the world, the Southern Railway was one of the largest users of colour-light signalling, and while other administrations were experimenting with new types of control machine, the power frame with all-electric interlocking remained standard practice for the largest schemes on the Southern, of which the last to be brought into service prior to the British Transport Commission's modernisation plan were at the complicated series of junctions to the north of Croydon, and also dealt with Purley. The decision to adopt control panels for the Kent Coast lines, instead of miniature-lever power frames, thus represented a notable change in Southern signalling policy for a large-scale installation, although a small control panel was installed at Keymer Junction early in 1958, and there was an earlier panel installation on the Waterloo and City Line in 1940.

The compactness of the panel type of control machines and the large areas that can, in consequence, be brought on to a single illuminated diagram gave ample opportunity for extending the sphere of control of the larger interlockings and for the elimination of many intermediate signalboxes. It is indeed significant of the new techniques that on so intensively used a line there are only three intermediate signalboxes in the 13¾ miles of suburban area between Herne Hill and Swanley. Beyond Swanley, while a number of mechanical boxes have been retained for local working of cross-overs and siding connections, the layouts are track-circuited throughout and all the main-line running signals are colour-lights. Arrangements are provided for switching out many of these intermediate boxes; in particular the entire section between Swanley and Strood Junction, 16 miles, is normally worked automatically, and the intermediate boxes are opened only as required for shunting, and so on.

East of Chatham the position is complicated by the existence of a number of level crossings. Six of these are infrequently used; they are normally closed to the roadway and the signals reading over them work as automatics. The signalboxes which were formerly block posts have been retained, but act merely as gate boxes. Three of these are between Gillingham and Rainham and the remaining three between Teynham and Faversham station. At Gillingham "B," Teynham station, Graveney Crossing and Westgate-on-Sea there are level crossings within the confines of the modernised mechanical interlockings, worked manually, while adjacent to the new power signalbox at Rainham there is a level crossing at which the gates are worked hydraulically. When a release switch on the signal control panel is operated, two ½ h.p. repulsion-induction pump motors start up in sequence, to build up the pressure. A red light indicates when pressure is available, and a push-button control is then operated to move the gates. At Teynham station the level crossing is operated by a porter-signalman when the box is closed.





Figs. 1 and 2—(Left) Shortlands Junction panel, with "push-push" control of entry-exit working. (Right) "NX" control panel at Faversham, the junction between the Ramsgate and Dover lines

The actual signalling, as presented to drivers, follows the standard practice of the Southern Region. East of Swanley the great majority of the colour-light signals are three-aspect, with four aspects when signal spacing is such that three aspects cannot provide adequate braking distance, or in the immediate approaches to certain stations. The layout is arranged to provide for a 2½ min headway between stopping trains between London and Herne Hill and in the Shortlands to Chislehurst area. Elsewhere, between London and Swanley, there is a 3 min headway for non-stopping trains. There is a 3 min headway between stopping trains through the crowded area of Rochester, Chatham and Gillingham, and also between Margate and Ramsgate. On the open stretches east of Swanley provision is made for a headway of 3 min between non-stopping trains. This has resulted in repositioning of colour-light signals throughout and in many cases there are no longer any posts corresponding to the former "home," "starting," "advanced starting" signals, and so on.

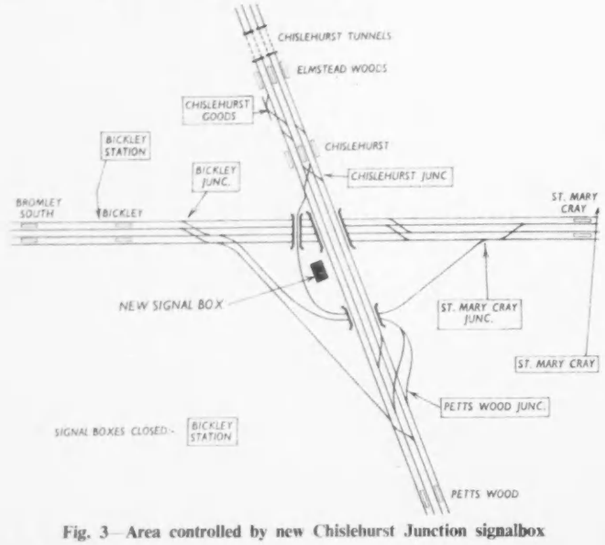


Fig. 3—Area controlled by new Chislehurst Junction signalbox

Principal interest is however centred in the control panels in the various power signalboxes. At Beckenham, Shortlands, Rochester, Rainham, Sittingbourne and Faversham the control panels are operated on the entrance-exit principle. The actuating units are placed in their correct geographical position on the panel and the signalman has to operate one function at the commencement of a route and one at the termination in order to set up a route (except for certain routes at Rainham, Sittingbourne and Faversham for which only one operation is required). Due to the urgency with which the installation was required to be completed, the line between Factory Junction (Battersea) and Ramsgate was divided into three sections, as follows :

(1) Herne Hill and Nunhead to Swanley, inclusive.

(2) Outside Swanley station to near Teynham, and the Sheerness branch.

(3) Teynham station inclusive to Ramsgate.

As a result, there are variations in the style and operating details of the control panels which follow the standard practice of the three contractors concerned. Thus, Beckenham (heading picture) and Shortlands (Fig. 1) have the Westinghouse "push-push" form of entrance-exit working ; Rochester, Rainham and Sittingbourne have the Siemens and General Electric Railway Signal Company's system, while Faversham (Fig. 2) has the original type of entrance-exit panel, the Metropolitan-Vickers-G.R.S. "NX" type. Shepherds Lane, Brixton, the first box of the series to be brought into service, has an all-electric power interlocking frame, and the Southern Region will continue to take advantage of the availability of all-electric lever frames already manufactured.

The largest and one of the most interesting of the new power interlockings is at Chislehurst (Figs. 3 and 4), where this main route is crossed by the former South Eastern main line from Charing Cross to Tonbridge. There are connecting lines between these two main routes, since some trains to and from the Kent Coast line are routed into Cannon Street, and the majority of the Continental boat trains travel via Tonbridge and terminate at Victoria. By a series of "flying" and "burrowing" junctions, these connections between the Tonbridge and the Chatham lines are made without any surface intersections of conflicting routes. This series of junctions was formerly controlled by no fewer than seven mechanical signalboxes, whereas now there is a single route-relay interlocking of the Westinghouse "one-control-switch" type as originally installed in the North Eastern area of the former L.N.E.R. at Hull, York

Fig. 4—"O.C.S." (one control switch per route) panel controlling the power interlocking at Chislehurst

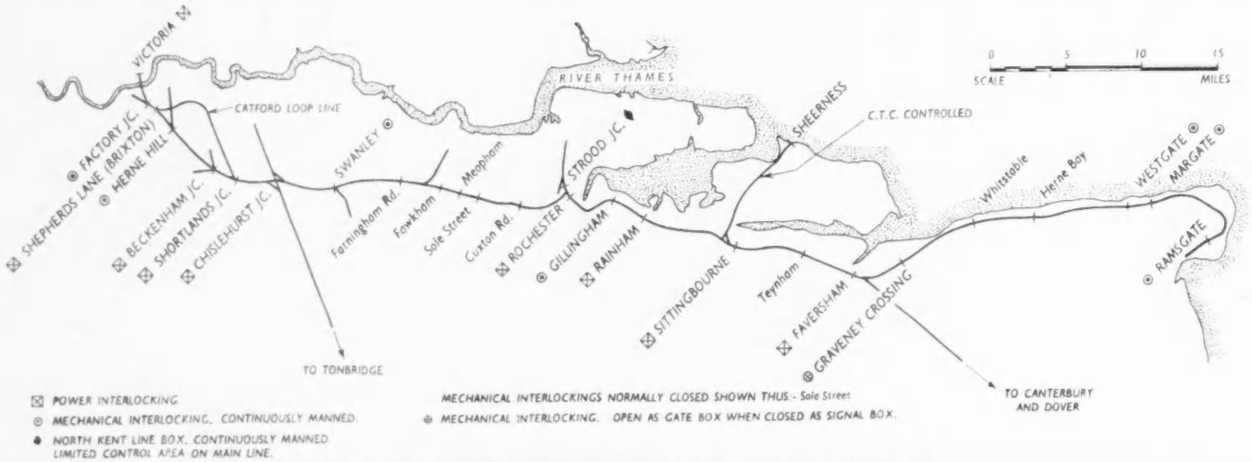


Fig. 5—Extent of colour-light signalling installed for the Kent coast electrification

and elsewhere. The accompanying sketch plan, Fig. 3, gives a good impression of the way in which control at this junction has been concentrated. Chislehurst Junction, it will be seen, controls a portion of the Charing Cross-Tonbridge main line, and although at present the signalling it controls on that route links up with mechanical signalling on either side, the Charing Cross-Tonbridge section will eventually form part of the complete electrification scheme to Tonbridge, Ashford and Dover, which will also be equipped with colour-light signalling throughout.

The extent of the signalling on the Kent Coast line is depicted on the map, Fig. 5. Reference to the scale will indicate the approximate length of sections between signalboxes; only the boxes open continuously are shown. This map includes the branch line to Sheerness. Connection to this is made by the system of triangular junctions immediately to the west of Sittingbourne and controlled from the new Sittingbourne power signalbox. In addition to the junctions at its entrance, the whole branch to Sheerness is controlled from Sittingbourne (Fig. 6), and provides an interesting example of modern technique in remote control signalling. One of the difficulties that has prevented adoption in this country of any of the American systems of remote control known collectively as Centralised Traffic Control (C.T.C.) has been the time taken for transmission of the codes by the relay systems employed; but the introduction of electronic methods has removed the previous limitations. The installation of the "Edict" system on the Sheerness line thus calls for description in some detail.

The right-hand portion of the panel at Sittingbourne controls the four interlockings on the Sheerness branch at Kemsley Halt, Swale Halt, Queenborough and Sheerness. The "Edict" (Electronic Digital Indicating and Control Transmission) system by which these relay interlockings are controlled and indicated is quite distinct from the signalling circuits themselves, which follow normal signalling practice. "Edict" was developed by the G.E.C. Telephone Works, Coventry, and supplied and installed by The Siemens and General Electric Railway Signal Company, Ltd. The branch is double track for the first $2\frac{3}{4}$ miles from Sittingbourne Middle Junction to Swale Halt, where the line singles to cross the Swale swing bridge and remains single, except for a passing loop at Queenborough, to Sheerness.

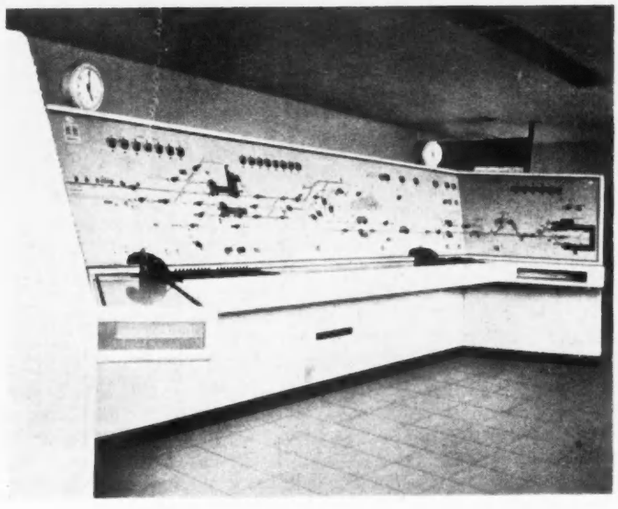
With the "Edict" system two operations can be initiated together and any number may be effected with a maximum delay in the present instance of 3·84 sec. Indications are returned within a similar interval of the controls taking effect. Movement of the panel key switches, which are precisely the same as those controlling the Sittingbourne area directly, operates relays, and the electronic apparatus "looks at" the condition of all relays in a continuously-repeated cycle (of 3·84 sec duration) and causes trains of pulses to be transmitted according to the "up" or "down" condition of the relay contacts. These pulses form the control signals, which must be directed to the appropriate outstation and operate the required equipment within it. This is accomplished by a scanning process at the outstations which is synchronised with that at the control point.

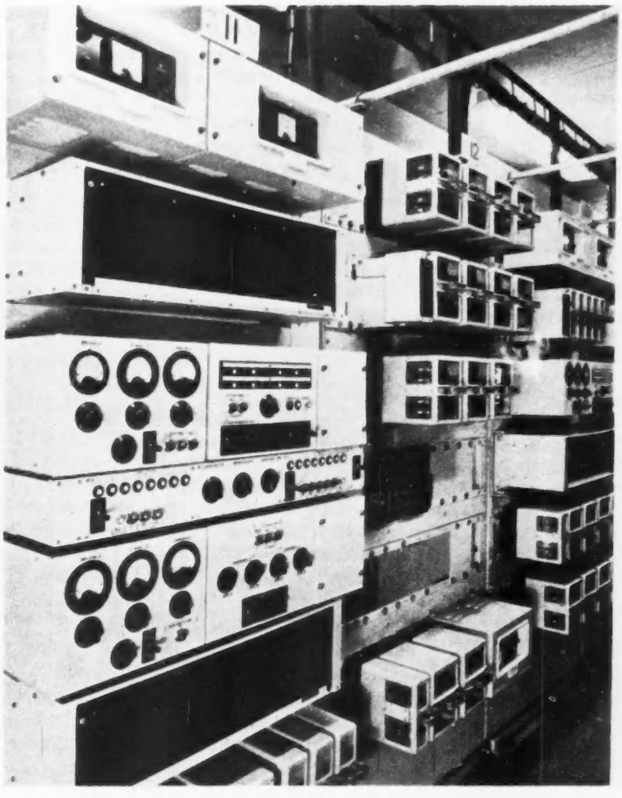
The control pulses associated with any panel switch or push-button are transmitted at a definite point in the scanning cycle; the synchronised outstation scan at the same moment directs the pulses to the corresponding piece of equipment. A similar system operates in the reverse direction to transmit and receive the return indications. It will be noted that; (1) controls are transmitted automatically within a brief interval from the switches being set; no "start" button is needed to initiate transmission as is often the case in C.T.C. systems using coded d.c. impulses; and (2) the codes need no identification elements, this being implicit in the part of the scan at which they are transmitted.

Continuous repetition of the cycle is obtained by the operation of a "distributor" consisting of cold cathode triode tubes connected in "ring" circuits in such a manner that the tubes in a ring conduct in turn, and when a tube conducts it extinguishes the glow discharge in the one before it in the ring. The timing of the process is controlled by taking one of the "triggering" inputs to the tubes from a mains frequency supply and connecting the trigger electrodes to gate circuits of such a nature that an output is applied to the trigger only when inputs from the timing source and the previous tube are present together.

In practice the ring type of distributor described above consists of several rings of tubes "rotating" at different speeds, and the 160 steps of the cycle are formed by different combinations of tubes in the various rings conducting simultaneously. At selected steps a group of relays is interrogated by a current pulse, and individual answering pulses according to the relay conditions are returned on subsequent steps. These responses are recognised by gate circuits, the outputs from which trigger further cold cathode tubes known as the "transmitter tubes" because they switch on transistor oscillators in the voice-frequency telegraph transmitters which transmit the control and indication pulses.

A single 40 lb cable pair carries the forward (control) and backward (information) information together with the locking pulses necessary for synchronising the various distributors, making five voice-frequency channels in all. The cold cathode tubes and associated circuits forming the distributors are carried in demountable assemblies on standard relay racks (Fig. 7). The various items of the voice-frequency pulse-transmitting and receiving equipment are housed in plug-in relay cases and fitted into bases on the same racks. Local control panels are provided at Kemsley Halt, Swale Halt, Queenborough and Sheerness for operation of the signalling on the spot if required.





Figs. 6 and 7—(Left) Sittingbourne panel controlling the local relay interlocking and, by an electronic system, the whole of the Sheerness branch. (Right) Electronic C.T.C. distributor equipment in standard plug-in relay cases at Sittingbourne

LETTERS AND LITERATURE

Letters to the Editor

(We do not hold ourselves responsible for the opinions of our correspondents)

EARNINGS OF ENGINEERS

SIR,—I was interested in the correspondence concerning the earnings of engineers, and particularly in Mr. E. M. Ackery's contribution (THE ENGINEER, November 6, page 566). An informal yard stick in general use for converting dollars into pounds sterling is six to one, but Mr. Ackery's ten to one may not be too wide off the mark. Personal taxation on this side of the Atlantic is not inconsiderable, particularly in income brackets above 12,000 dollars per annum and in addition there is considerable indirect taxation in the form of Federal and Provincial sales tax. This differs from the British tax, in so far as there is a 10 per cent Federal tax on all goods at source which is not necessarily disclosed in the retail price.

When making comparisons across the Atlantic, one should also make allowances for the many intangible values which accrue from a long-established and sophisticated society.

R. G. FULLER

Hudson, P.Q.,
December 10, 1959.

BEATING INFLATION

SIR,—In your issue of August 14, 1959, you make an interesting comment on "Beating Inflation by Lowering Prices," and you are eminently quotable in saying "economists do not know how to control an economy," and that none of the proposals of the Council on Prices "seems to have been particularly successful in preventing inflation." You seem to have assumed that economists have an ethical purpose to recommend a "good and just" course of action. However, leading professional economists are interested in becoming part of the ruling clique, and they have a desire for the economy to need planning (by them, of course). A just self-balancing economy with strong tendencies to full employment and more productivity without inflation would not suit them at all; they would be out of a job, and they, therefore, prefer a confused, complicated system with plenty of arbitrarily added traps, so that their expert hands may continually be needed at the control.

On the other hand, many economists are not in line for the ruling class and they are paid, subsidised or otherwise controlled indirectly by people or institutions which are concerned with retaining certain privileges. An economist is a "mercenary," he must be wary both as an adviser and as a teacher to see that some "dangerous" ideas are kept submerged and unclarified. Hence, the popularity of that superb camouflager, Keynes, in the west, and profound old confusers, Marx and Engles in the east. Keynes was right in saying that unemployment could be prevented by inflation, although he did not use that term. He did not advertise that, in the long run, prices and wages would rise continuously. Keynes offers the choice: communism or steady inflation. Most professional economists merely suggest arbitrary interference to treat the symptoms of the disorder, and they avoid fundamentals.

Although there may be others, the biggest hindrance to productivity, efficiency and full employment is the discouragement to labour, enterprise and commerce which results from taxation. The taxation system can be changed so that it encourages enterprise, efficiency, and the optimum use of resources and labour. This could readily be done by greatly reducing taxes on labour, exchange and capital (i.e. income tax, sales tax, profits tax, &c.), and obtaining revenue by a heavy uniform tax on the value of all land sites. This is quite practical, as has been shown to considerable extent in Australia, New Zealand, Denmark, Jamaica, &c., although in these countries there are speculators who are interested in removing such tax.

Site value taxation reduces the price of the taxed item, it is not inflationary. The tax cannot be passed on without passing on the equivalent amount of service and it would allow reduction of the other taxes which do raise prices and are inflationary. A change to taxing site value is therefore double-barrelled. The reduction in prices of goods would occur without a reduction in wages or in the profits of true capital investment. The tax encourages owners to use sites to the full, or to let someone else use them efficiently. This is a continuing stimulus to full employment (without inflation). It may be claimed that this is socialisation of land. However, the "socialisation" is only of the privilege of owning the title; it is not nationalisation; the tax would in no way interfere with the way the privilege was used. It merely makes it economically difficult to own sites without using them fully. Idle land would no longer be "used" for speculation or as a hedge against inflation.

In any case, existing taxes are just as much "socialisation," for they socialise human effort and confiscate the return for thrift and enterprise. It is surely better (economically) to tax privilege than to tax productivity. The ownership of a privilege is unproductive and is of no virtue. When a privilege is taxed, it is transferred to the whole of the community. The cost of the privilege is thus removed from the price structure. This would strengthen the nation in the competition for oversea markets. Space forbids detailing with other favourable characteristics of site-tax over other taxes except to mention: cheap to assess and collect, no clerical work for payer, impossible to evade, fully secured, directly proportional to privilege received, and accords with ability to pay.

Because many of us have a small amount of privilege in site owning, we are frightened to lose it, even though we would gain much more by lower prices and better returns from wages and salaries, and from enterprise investments, and by more efficient production. This would be particularly the case with professional engineers, and others who get their living mainly by providing labour and skill.

S. S. GILCHRIST

Sydney,
Australia,
December 14, 1959.

COPPER AND BRASS TUBE MILL AT NEW MILFORD

SIR,—In your issue dated October 30, mention was made on page 534 of a copper and brass tube mill at New Milford. Much of this equipment was provided by Blaw Knox/Aetna Standard Engineering Company and your readers may care to know that The Head Wrightson Machine Company, Ltd., are the exclusive licensees for the sale and manufacture of Blaw Knox/Aetna Standard equipment in the United Kingdom.

W. C. PATERSON,
Chief Publicity Officer,
Head, Wrightson and Co., Ltd.

Ship House,
20, Buckingham Gate,
London, S.W.1,
December 7, 1959.

FREE-PISTON GAS TURBINE DRAUGHT

SIR,—I have read with great interest Mr. S. B. Jackson's paper in THE ENGINEER dated November 27, 1959, pages 692–696. His method of combining gas generators, a gas turbine or turbines and a steam turbo-alternator is ingenious, but I find some of the details rather surprising.

For recovery of heat in boiler flue gas below the datum of 320 deg. Fah. he proposes to generate saturated steam at 55 lb per square inch gauge and to give this 50 deg. of superheat in a separately-fired superheater. I do not know what condition he assumes for the main steam flow at this pressure, but if the addition of 3·5 per cent in a saturated condition is not acceptable, it would seem simpler to obtain the desired superheat from the gas at entry to the main economiser. This would, according to my calculations, provide the stated quantity of 28,900 lb per hour at 350 deg., the temperature of gas leaving the main economiser falling to 315·5 deg., but that leaving the recuperator remaining at 200 deg. Fah. Adjustment of the recovery ratio, as between the economiser and the recuperator, would enable the chosen intermediate gas temperature of 320 deg. to be restored.

The presentation of total generation cost on a basis of steam side output alone is puzzling; if the cost for the combined cycle is plotted on the, to me at least, more logical basis of total station output, there would seem to be no significant difference between the two curves, the conclusion that a 150MW station is more efficient than a 120MW station occasioning no very great surprise. The case for the combined cycle would thus appear to rest on qualitative grounds. Examining these, it would appear that the argument in favour of standard small gas turbines could well be applied to

the gas-turbine alternator, which could be divided into five self-contained units each served by a group of seven free-piston generators. No spare generators would then seem necessary, after-burning corresponding to 25 per cent increased output providing the standard power of, say, 28,800kW from four units. A forced draught fan taking about 150kW would supply the balance of the boiler air requirement. All normal auxiliary drives, including the steam turbo-alternator barring gear, would be electrical and would seem to lie within the capacity of one gas-turbine alternator unit.

T. C. S. POINTON

Northwich,
Cheshire,
December 15, 1959.

Book Reviews

Jane's Fighting Ships, 1959-1960. Edited by R. V. B. BLACKMAN. Sampson Low, Marston and Co., Ltd., Potter Row, Great Missenden, Bucks. Price 105s.

IT is many years since naval building programmes aroused keen interest because of the effect they would have on the comparative strength of the world's navies. None the less, year after year, in each edition of "Jane's" there are a substantial number of new photographs, technical data and descriptive notes, for which the large building and conversion programme of the United States Navy is to a considerable extent responsible. As in previous years, the publishers in their foreword summarise the principal changes in each navy and give their views on the types and roles of the ships now building and which will be built in the future. Casting doubts on Mr. Krushchev's statement that Russia is to scrap 90 per cent of her cruisers, the foreword emphasises the views we have ourselves expressed on Soviet naval policy but omits to explain why. "The Soviet leaders believe they have the numbers and types of ships to cut the Atlantic lifeline, deny Britain and the United States the control of the seas off Europe and Asia and induce N.A.T.O. to call a halt to any hostile operations." This clearly makes sense in a major war developing from a local war overseas. But N.A.T.O. defence policy is based on a major war fought in Europe with H-bombs against which—as is rightly emphasised in the 1957 Defence White Paper—there is no adequate protection for the people of this country. Indeed, after studying the United States section of "Jane's"—which occupies about one-quarter of the book—the reader will be unfavourably impressed with the difference in the defence outlook between our two nations. Despite the vast numbers of U.S. carriers and cruisers, Britain is only able to contribute two ships in each of these categories to the defence of the sea routes in the wide oceans.

The disparity in the strength of the two navies is clearly shown in a new and valuable feature of this volume which gives a two-page table of the numerical strength of all navies. Though the United States Navy intends to equip its future ships with nuclear-power plants, it is hardly possible to concur in "Jane's" forecast that "all major warships can be expected to be nuclear-powered within ten years." Nor in the statement that the strategic advantages of such ships are "staggering." Nuclear-power plants have certainly revolutionised both the offensive and defensive capabilities of the submarine. But the advantage to a surface warship lies mainly in her greatly increased endurance at high speed. Having regard to the time taken to build large warships at the present time—and to Britain's defence policy—can anyone imagine that our seven carriers and three "Tiger" class cruisers will be replaced by nuclear-powered vessels by 1970? On the other hand, with the new emphasis in the United States on mobile deterrent missile launching platforms, the forecast made of forty "Polaris" submarines by 1967 is probably accurate, though each of them costs at present no less than £38,000,000! Nine of the thirty-three nuclear-powered submarines already built, building or authorised, are of this type. But in pointing out that, fourteen years after the end of the war, Britain does not yet possess one nuclear-powered submarine, nor one operational guided missile ship, "Jane's" seems to forget the cost of these ships and, above all, the basis of British defence policy. Unless that policy is changed, the taxpayer will not be encouraged to provide new ships for a localised campaign overseas.

The publishers' comments on cruisers are logical and of great value. Though the main threat now comes from below and above the sea, the cruiser is a self-contained fighting unit and is the only class of vessel capable of protecting a carrier against surface ship attack and of identifying and dealing with an armed raider reported by her aircraft 100 miles away. Nor must it be forgotten that existing guided missiles with which United States cruisers and the new British fleet escort destroyers are being equipped are anti-aircraft missiles. The surface warship's main armament is still her aircraft or her guns. "Jane's" might well have emphasised this point, in view of the growing tendency to belittle the value of the aircraft carrier.

The Russian section confirms the view—already admitted by high ranking Soviet naval officers—that Russia, after a pause in constructing underwater vessels, is now building nuclear-powered submarines, though their size—only 3000 tons, according to "Jane's"—suggests that they are not of the ballistic rocket launching type. The Netherlands section in this volume is of particular interest. But one would like to have heard more about the two 1240-ton submarines under construction at Rotterdam "with electric propulsion on the surface"—presumably diesel-electric—"and with a triple hull permitting greater diving depth." Two others—originally of the same design—are to be converted to nuclear propulsion.

The Concise Encyclopædia of World Railway Locomotives. Edited by P. RANSOME-WALLIS. Hutchinson and Co. (Publishers), Ltd., 178–202, Great Portland Street, London, W.1. Price 50s.

NINE authors have contributed to this 512-page book, which succeeds in presenting an overall picture of railway motive power of much value to the general reader. There are some differences of method between the various chapters, and only that on the construction and design of the reciprocating steam locomotive is in alphabetical encyclopædia form, but all chapters are subdivided in a way which should help in finding a wanted piece of information. The merit of the book in comparison with many works on railways for general consumption lies in its numerous annotated drawings; those on mechanical and hydraulic transmissions for diesel traction will be particularly welcome. The steam locomotive drawings, also, are a useful source of reference, for how many of the railway enthusiasts who debate locomotive performance so hotly could draw a firebox with thermic syphons, or a modern smokebox interior, if challenged? It is a pity, however, that the chapter on "Electric Motive Power" contains no circuit diagrams or details, and only two drawings of any kind, both relating to the somewhat unconventional "16500" class B_0–B_0 of the French National Railways with its variable gear ratio. A place should have been found here or in the diesel section, at least, for a drawing of that much-quoted but rarely-visible object, the axle-hung, nose-suspended traction motor.

Chapter I on "Diesel Railway Traction," by J. M. Doherty, consists of sections on engines, transmissions, locomotives, railcars and trains, and miscellaneous equipment. It is followed by a review of diesel traction in North America by David P. Morgan, which concludes by summarising the activities of the various locomotive manufacturers in the United States and the diesel operating practices of the railways. F. J. G. Haut, the author of the chapter on "Electric Motive Power," is well known for his researches in electric locomotive history and traces significant events in the development of electric traction from 1879 to the present day. He brings the story up to times as recent as the Paris–Lille electrification of the French National Railways and the Kent Coast scheme of the Southern Region.

The steam locomotive is the subject of five chapters dealing with its principles, construction, design practice in various countries, testing, and operation in traffic. C. R. H. Simpson, the first of the six authors in this section, follows his useful encyclopædia mentioned already with a further alphabetical part on steam locomotive experiments, in which the reader may look under headings such as boilers, compounding, valves, and so on for brief accounts of the less familiar forms taken by these components from time to time. Other contributors on the steam locomotive are H. M. Le Fleming, S. O. Ell, O. S. Nock, G. Freeman Allen, and P. Ransome-Wallis (the editor). Some celebrated runs with steam power are recalled by O. S. Nock writing on the steam locomotive in traffic, where sub-sections entitled "Psychology in Running" and "Allocation of Engines to Crews," remind us of the human factors which give steam locomotive performance its variety and fascination.

In the concluding chapters the editor writes on unconventional motive power and the gas turbine in railway service. A misplaced footnote confuses the Brown-Boveri locomotive of 1943 with the Metropolitan-Vickers design of 1951 which was rebuilt in 1958 as a 25kV a.c. locomotive for crew training. A very brief concluding section on free-piston gas generators deserves amplification, for only a small proportion of the readers of a book such as this can be expected to understand the term. There are 128 half-tone plates, some comprising three or four pictures on a page, and sixteen full-page plates in colour. A section of biographies of famous locomotive designers is followed by notes on wheel arrangements, a glossary of English and American railway terms, and a bibliography.

Proceedings of a Symposium on the Strength of Concrete Structures. London, May, 1956. 697 pages. Cement and Concrete Association, 52, Grosvenor Gardens, London, S.W.1. Price 100s.

IN the last fifteen years increasing interest has been shown in the failing load conditions of reinforced concrete structures. This has

perhaps been sparked off by Professor J. F. Baker's researches into the failing load of steel structures. The two problems have certain similarities, but, of course, many differences, particularly after yield has been reached. This interest has been stimulated by the growing awareness among engineers that they have little idea of the real strength of a structure and that the failing load very rarely bears any relationship to the load the structure has to carry in its normal life. The symposium, of which this book is the record, was held to provide a forum for the exchange of ideas on the subject.

It was divided broadly into five sections although some overlapping occurred. In the first section one paper was devoted to a fundamental and critical analysis of the design loads generally assumed for buildings and their relevance to practice. Very often design loads far in excess of actual loads are assumed and great economy in design may be found by further research in this field without looking in any other direction. In this section, too, is an interesting paper which is devoted to a statistical analysis of all the factors which will influence the probability of failure, i.e. the strength of the concrete and steel, the applied load and their deviation from nominal values. The application of this method to a building in Stockholm reduced the amount of steel by 30 per cent. The discussion on these papers was very limited and indicates that few engineers are yet prepared to apply statistics to their problems. This undoubtedly, however, will have to be one of the future approaches.

The second section is devoted essentially to the ultimate strength of single members. The papers, although they are adequate presentations of the problems, add little to already published data and their analysis, and in fact the results have been largely incorporated in codes of practice. There is one exception, that dealing with torsion. This paper takes us a little on the way, but also reveals how much more has still to be learned.

In the third, and probably the most interesting, section the authors of the papers have attempted to come to grips with the intractable problem of continuous frames, both determinate and indeterminate. These excellent papers by Professors A. L. L. Baker and P. B. Morice and M. Guyon carry the subject a great deal further, even if the experimental data are a little meagre. M. Guyon's paper is well up to the standard which we now expect from this eminent French engineer. The discussion in this section is excellent and the best in the whole book.

The fourth section is devoted to three excellent research papers, one on concrete walls, one on dynamic loading and one on bridge decks. The first two contain valuable data which are presented here for the first time. In the last section the application of ultimate load theory to codes of practice is discussed, but this has been overtaken by events in that the codes have now been published.

The whole makes an interesting book and contains a large amount of useful information. It is, of course, a pity that three and a half years have elapsed since the conference, but this appears to be the fate of the records of such symposia these days. One does wonder whether the time to produce and the cost could be cut down if a great part of the discussion could be omitted. The reviewer would like to suggest that the discussion which occasionally appears to be completely irrelevant could be submitted to an independent committee to judge whether it should be included in the official record. Although the papers are valuable a great part of the discussion (except where noted) is of little account.

Experimentelle Untersuchungen an geraden und gekrümmten Diffusoren. By H. SPRENGER. Mitteilungen aus dem Institut für Aerodynamik an der eidgenössischen technischen Hochschule in Zürich. No. 27. Zürich: Verlag Leemann, Arbenzstrasse 20, Zürich 34. Price Sw.Fr.17.

As regards the details of the behaviour of diffuser sections in pipes and ducts, a good deal of clarification is still required in a field in which the mathematical difficulties severely hamper a theoretical approach. The present work is concerned experimentally with the flow patterns and pressure conversion in diffusers, much attention being paid to an accurate definition of the experimental conditions. A 12kW open current wind tunnel was used and measurements were extended to $Re = 8 \times 10^5$. At Mach numbers up to 0·3 the flow could be regarded as incompressible. Fourteen straight and curved diffusers with inlet diameters of 10cm were employed. Ten of these had the same axial distributions of cross-sections. The basic form was a straight circular conical diffuser of 8 deg. total vertex angle and an area ratio of 1 : 4. The other nine diffusions were derived by curving the axis to a varying extent, and by area-preserving affine transformations of the circular section into non-circular shapes. These diffusers were similar to the draught tubes of water turbines and diffuser passages of pumps and blowers. In the region where the conversion of flow velocity into pressure begins, conditions were investigated with the aid of a short precision diffuser. The results were compared with a straight conical diffuser of 6 deg. total vertex angle and a pipe with sudden expansion of cross-section. Ways of improving the efficiency of conversion of kinetic energy into pressure which were investigated include boundary layer suction, generation of artificial secondary flows and the method of separating the decelerating and bend sections. A procedure due to Professor Ackeret for calculating straight diffusers with turbulent flow was here employed for the first time. The investigation is to be continued to include measurements of turbulence and cases of compressible flow.

Books Received

County Borough of Grimsby Official Guide. Batiste Publications, Ltd., 20, Bedford Street, London, W.C.2.

Colliery Year Book and Coal Trades Directory, 1959. Iliffe and Sons, Ltd., Dorset House, Stamford Street, London, S.E.1. Price 40s.

A Short History of Scientific Ideas to 1900. By C. Singer. Oxford University Press, Amen House, Warwick Square, London, E.C.4. Price 35s.

Lehrbuch der Hochspannungstechnik. By G. Lesch. Springer-Verlag, Berlin-Wilmersdorf, Heidelberger Platz, 3, Western Germany. Price DM.39.60.

The World's Lighthouses before 1820. By D. Alan Stevenson. Oxford University Press, Amen House, Warwick Square, London, E.C.4. Price 63s.

Heizöl-Handbuch für Industriefeurungen. By W. Hansen. Springer-Verlag, Berlin-Wilmersdorf, Heidelberger Platz 3, Western Germany. Price DM.31.50.

The Elements of Determinants, Matrices and Tensors for Engineers. By S. Austen Stigant. Macdonald and Co. (Publishers), Ltd., 16, Maddox Street, London, W.1. Price 60s.

Grosse Dampfkraftwerke Planung, Ausführung und Bau. Vol. I: *Kraftwerksatlas*. By K. Schröder. Springer-Verlag, Berlin-Wilmersdorf, Heidelberger Platz 3, Western Germany. Price DM.192.

British Standards Institution

All British Standard Specifications can be obtained from the Sales Department of the Institution at 2, Park Street, London, W.1.

ENAMELLED COPPER CONDUCTORS (ENAMEL WITH POLYESTER BASE). PART 1 : ROUND WIRE

No. 3160 : Part 1 : 1959. Price 8s. 6d. This publication extends the range of British Standards for enamelled winding wires to include enamels based on terephthallic acid polyester resins, which are generally suitable for higher operating temperatures than those of the polyvinyl acetal type covered by B.S. 1844. The requirements in the standard are similar to those specified in B.S. 1844 : Part 1, but some of the test temperatures are 30–50 deg. Cent. higher. The range of wire sizes standardised extends from 0·002in diameter to 0·16in diameter. Four standard thicknesses of covering are provided over most of this range.

HIGH STRENGTH FRICTION GRIP BOLTS FOR STRUCTURAL ENGINEERING. PART 1 : GENERAL GRADE BOLTS

No. 3139 : Part 1 : 1959. Price 7s. 6d. This thirty-two-page publication provides for one grade of quenched and tempered high strength friction grip hexagon head bolts and for their associated nuts and washers. Dimensions are given for a range of nominal sizes from ½in to 1½in inclusive, and data in the tests are "keyed" to annotated diagrams. Mechanical properties are specified, as are tests, inspection procedure and marking provisions. The designation "high strength friction grip bolts" has been adopted to distinguish the product from other types of high tensile bolts by indicating the mode of application.

MECHANICAL TESTING OF STEEL AT ELEVATED TEMPERATURES. PART 3 : 1959 : NON-INTERRUPTED CREEP TESTING ; PART 4 : 1959 : INTERRUPTED CREEP TESTING

No. 3082. Price 4s. each. These new Parts 3 and 4 of the series of standards which will deal with the mechanical testing of steel at elevated temperatures are based on the work undertaken by Technical Committee 17 "Steel" of the International Organisation for Standardisation. In both parts, definitions of gauge length, stress and permanent percentage elongation are followed by requirements for the test piece. The methods for the determination of creep strain are given, as are the temperature limits within which the heating apparatus must operate ; the methods of measuring temperature are also specified. Other requirements deal with accuracy of the testing machine, axiality of loading, the correct functioning of the extensometer, temperature and creep readings and the presentation of the results.

T-BARS (UNIVERSAL, HEAVY FLANGE AND LONG-STALK)

Supplement No. 1 (1959) to B.S. 4A (1934). Price 5s. The primary object of this supplement is to specify Universal T-bars cut from the Universal beams and column sections published in B.S. 4B. When this supplement and B.S. 4B were prepared it was felt advisable to incorporate in them requirements for the broad flange beams and the T-bars previously specified in B.S. 2566. Hence, the supplement deals also with the heavy flange T-bars and the long-legged T-bars (now called long-stalk T-bars) originally covered in B.S. 2566, which is now withdrawn. A new method of designating the various sections has been adopted. Previously, British Standard sections were designated by letters and numbers which were quite arbitrary, but experience has shown that this method is rarely used in industry, the sections usually being designated by their leading dimensions. It was therefore decided to follow the common practice and a section is now designated by its nominal size in inches and its weight per foot in pounds. The supplement specifies not only the dimensions of the sections, but also properties such as moments of inertia, radii of gyration, elastic moduli and plastic moduli.

METHODS OF TESTING VULCANISED RUBBER : PART A.20, DETERMINATION OF HARDNESS (MICRO-INSTRUMENT)

No. 903 : 1959. Price 3s. The use of a micro-instrument for the testing of small and thin test pieces is the point which distinguishes this part of the revised B.S. 903 from the standard hardness test specified in Part A7 of the same standard. The micro-hardness test—applicable to samples down to 1mm thickness—is, in fact, a "scaled-down" version of the test in Part A7.

After an explanatory note, separate sections of the publication deal with test piece, apparatus, procedure, temperature of test, and form of report. The standard concludes with a table for the determination of hardness in British Standard and International Rubber Hardness degrees for instruments calibrated in millimetres.

THE ENGINEER

Technical Contributors Section

DECEMBER 1959

Measuring, Classifying and Counting Wheel Loads of Moving Vehicles

By J. J. TROTT, B.Sc., A.Inst.P.,* and P. J. WILLIAMSON, B.Sc.*

An apparatus has been developed which automatically weighs vehicles as they move along the road at normal speeds and counts the number of wheel loads in predetermined weight groups. The equipment consists of a weighbridge installed in the road and supported on four load cells. The strains produced in the load cells by a vehicle crossing the weighbridge are measured by resistance strain gauges, the output of which is fed to a reflecting galvanometer. The deflection of the galvanometer is proportional to the load applied to the weighbridge. The optical system of the galvanometer is so arranged that it can be used to classify the loads.

IN investigating the performance of a road pavement it is necessary to know how many vehicles have travelled along the road since completion of construction and the magnitude of their wheel loads. Estimates of these data are sometimes made by surveys lasting for, say, a week and repeated at intervals during the life of the road. Until recently, in surveys carried out by the Road Research Laboratory the number of vehicles passing an observation point were counted manually and the vehicles were classified into weight groups by estimating weights from certain easily visible characteristics, such as the number of axles and the arrangement of the wheels. The weights associated with each class of vehicle were obtained by stopping and weighing a number of those in each group. The method was laborious and impeded traffic, and was subject to errors outside the control of the operators. In consequence, the Laboratory has now developed equipment which automatically weighs vehicles as they move along the road at their normal speeds and counts the number of wheel loads in predetermined groups.

This article describes the apparatus, indicates the difficulties encountered, and suggests ways of overcoming those associated with the equipment. The apparatus has been used to count and classify the traffic travelling northwards over the Laboratory's full-scale experimental sections on the Great North Road (A.1) at Alconbury Hill, Huntingdonshire.

* Road Research Laboratory, Department of Scientific and Industrial Research.

American Work

In 1952, the American Bureau of Public Roads published a report[1] on the development of a weighbridge for weighing vehicles in motion. The weighbridge consisted essentially of a platform set level with the road surface and supported on four load cells giving an electrical signal proportional to the load applied to the weighbridge. The signal was observed on an oscilloscope and the observer counted the number of times the cathode-ray spot was deflected beyond certain levels corresponding with various weights. Some of the oscilloscope deflections were photographically recorded. When the equipment was produced commercially, the electrical signal from the load cells operated a pen recorder, the paper roll of which was set in motion when a vehicle approached the weighbridge : this gave long lengths of record with thousands of deflections per day to be measured when a survey was made on a busy road.

Design of R.R.L. Apparatus

The equipment is in two separate units : (1) the weighbridge, which is installed in the road at the point at which measurements have to be made, and (2) the weight-classifying and counting equipment which is moved from site to site as surveys are required.

The equipment must have a sufficiently low current consumption to permit operation from batteries, because experimental road sites are usually far from the electric mains. Economy in power consumption is achieved by using a recording system of limited resolution whereby all wheel loads are classified into ten groups, and by using transistors in the circuits operating electromagnetic registers. Classification of the weights is achieved optically, thus avoiding voltage comparison techniques involving additional circuits.

The transverse distributions of traffic recorded in the manual surveys indicated that a weighbridge platform 6ft long extending from 1ft to 7ft from the kerb would carry a high proportion of the nearside wheels, or

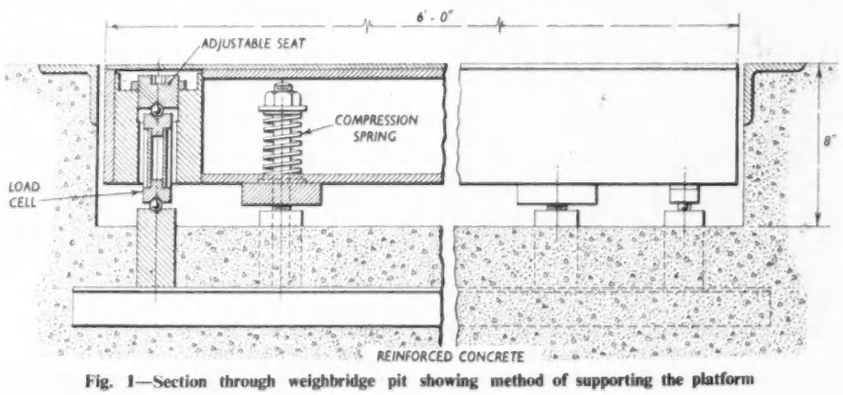


Fig. 1—Section through weighbridge pit showing method of supporting the platform

pairs of wheels in cases where there are twin wheels at each end of an axle. A width of 2ft (measured along the length of the road) would provide an electrical signal of sufficient duration to operate the classifying and counting circuits. Some vehicles have twin axles 5ft to 6ft apart. When the distance apart is 5ft, and the vehicle is travelling at 40 m.p.h., the time interval between the passage of each axle is 0·085 second, while the interval between the wheel on the first axle leaving the weighbridge and the second wheel coming on to it will be about 0·050 second. It is essential to weigh such wheels separately; thus the width of the platform must be restricted to 2ft in order to provide adequate separation of the electrical signals, and recording equipment is needed capable of classifying and counting electrical signals about 0·050 second apart. That this has been achieved in the Road Research Laboratory apparatus has been confirmed experimentally.

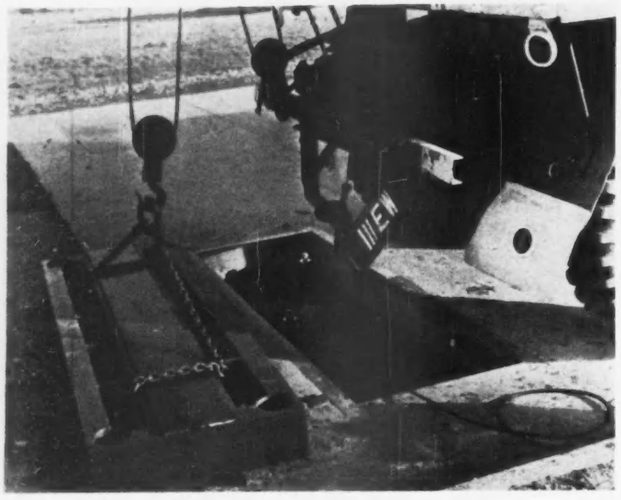


Fig. 2—Weighing platform and pit at the Alconbury Hill site

The weighbridge platform is designed to carry loads of up to 20,000 lb on a single wheel. It consists of a main rectangular frame of 6in by 3in I-section with lateral stiffeners of ½in steel plate. The frame is covered with three sections of ⅜in steel plate. Fig. 1 shows a section of the platform which is supported on four load cells, one at each corner. Static compression of the load cells was found necessary for satisfactory operation, and this is achieved by the spring shown in Fig. 1. There are three such springs and their positions are shown in Fig. 2, which also shows the platform before installation with the two outer sections of cover plate removed to give access to the load-cell housings at each corner. The total depth of the platform is 7¼in and it requires a concrete-lined pit 7¾in deep.

The concrete below the floor of the pit is heavily reinforced and the seatings of the load cells are carried on a frame of 2in by 2in by ¼in steel angle bonded to the reinforcement and embedded in the concrete. This frame also carries three screwed sockets for the studs which are used to locate the platform in the horizontal direction and also carry the springs for applying downwards precompression to the load cells. The upper edges of the concrete pit consist of 3in by 3in by ⅜in steel angle.

The weighbridge platform rests on four load cells of beryllium-copper, each designed to carry a load of 25,000 lb without permanent deformation. They consist essentially of cylinders 3in long by 1in diameter, bored out to give a cross-sectional area of ½ square inch. Hardened steel caps are provided at both ends (see Fig. 1) to transmit the load uniformly to the cell. Fig. 3 shows a load cell with one end cap removed to show the end of the beryllium-copper cylinder.

The outer cylinder, shown in Fig. 3, is a protective sheath of $^{1}/_{64}$in thick brass sheet. The space between the sheath and the load cell is filled with waterproofing wax. To provide for a possible slight misalignment of the top and bottom seatings of the load cell, the load is transmitted to the cell through a ¾in diameter steel ball at each end (see Fig. 1) and the platform can be levelled by raising or lowering the upper seating which is screwed into the load-cell housing.

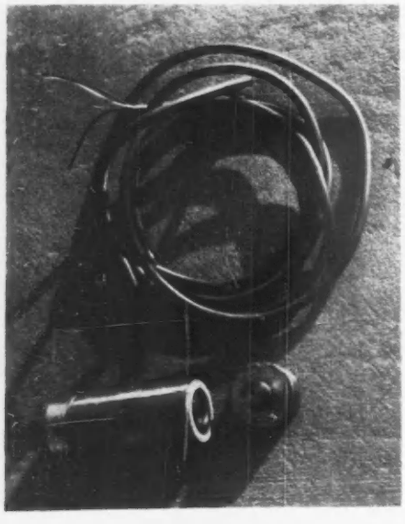


Fig. 3—Load cell

Load Measurement and Classification

Strains produced in the load cells by a vehicle crossing the weighbridge are measured by resistance strain gauges attached to the surface of the beryllium-copper cylinders with Araldite D adhesive. The output from the strain gauges was to be fed without amplification direct to a galvanometer of 50 ohms resistance; thus it was necessary to use strain gauges of resistance roughly equal to that of the galvanometer and capable of carrying high current to give maximum sensitivity. For these reasons, foil resistance strain gauges are used having a resistance of 55 ohms. Four strain gauges are cemented to each load cell, two parallel to the axis of the cylinder and two perpendicular to it, so that, under load, two gauges are in compression and two in tension. The sixteen gauges are connected to form a resistance bridge, as shown in Fig. 4. The bridge is supplied from a battery, the voltage of the supply being adjustable and determining the load range of the weighbridge. The output of the resistance-bridge network is fed to a reflecting galvanometer with a deflection time, under conditions of critical damping, of 0·013 second, which is adequate to respond to the short electrical pulses generated by moving vehicles. The deflection of the galvanometer is proportional to the load applied to the weighbridge.

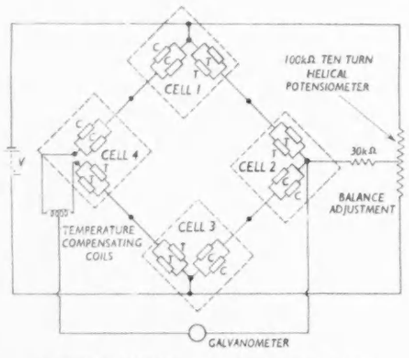


Fig. 4—The bridge circuit connections of the load cell strain gauges

The optical system of the galvanometer is shown in Fig. 5 and is used to classify the loads. Light from the lamp *S* is reflected by the galvanometer mirror *G* and the fixed mirror *M* and is formed into a narrow band by the cylindrical lens *L*. When the galvanometer is deflected, the band of light sweeps across the line of ten photo-electric cells *P*. A sharp leading edge is given to the band of light by the straight edge *E*, placed so that its image lies in the plane of the photo-electric cells. Each photo-electric cell is connected to a switching circuit, as shown in Fig. 6. When the photo-electric cell T_1, a photo-transistor, is illuminated, a voltage

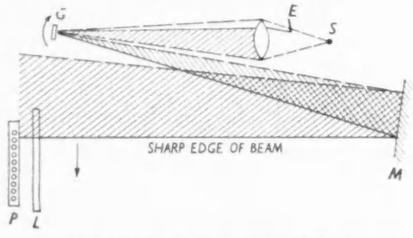


Fig. 5—Optical system of load classifying apparatus

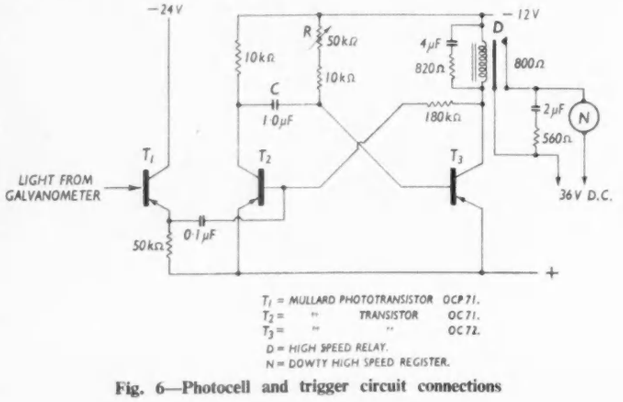
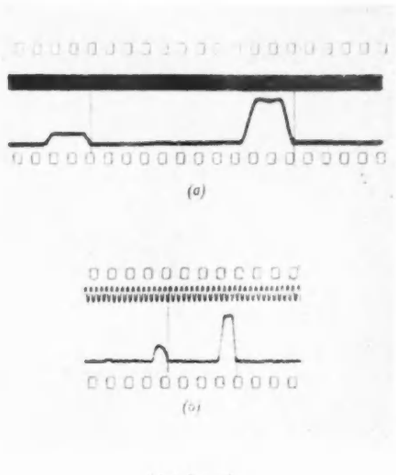


Fig. 6—Photocell and trigger circuit connections



(a) 0·5 m.p.h.
(b) 28 m.p.h.

Fig. 7—Oscillograms produced by a vehicle in testing the response of the system to dynamic loads

pulse is applied to the transistor T_2, causing the current through the high-speed relay D to be cut off for a period of time dependent on the values of the capacitance C and the resistance R. This closes the contacts of the relay D and completes the circuit through the high-speed electromagnetic register N. Thus, every photo-cell illuminated by the deflection of the galvanometer causes a register to operate, and the number of wheel loads in any class is given by the difference of the readings of the two registers corresponding to the weight limits of the class. The wheel load at which a register operates is controlled by the lateral position of the photo-electric cell and by the voltage applied to the load cells. In the present apparatus, the photo-electric cells are spaced at regular intervals from the zero position of the band of light from the galvanometer. The galvanometer lamp is a 12V, 24W, automobile headlamp bulb and is the principal drain on the electric power supply. The resistance bridge and the trigger and counting circuits have a combined power consumption of less than a watt.

The accuracy with which the limits of a weight group are defined is determined by the width of the photo-cell aperture in relation to the distance between the apertures. The width of the aperture is dependent on the intensity of the light received from the galvanometer and, with the present optical arrangements, the photo-cell aperture is $\frac{1}{16}$ in. The distance between apertures is $\frac{9}{16}$ in, so that, when the electrical circuits are adjusted to record wheel loads in steps of 1000 lb, the maximum error is $\pm^1/_9$ times the weight interval and is ± 111 lb.

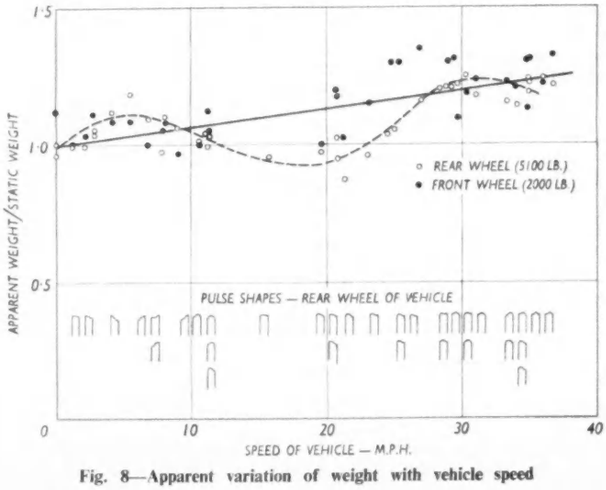


Fig. 8—Apparent variation of weight with vehicle speed

Calibration

A static calibration of the weighbridge can be made by loading it by a hydraulic jack acting against a loaded trailer, and observing the galvanometer deflections corresponding to readings of the jack load gauge for a standardised value of the voltage applied to the resistance bridge. The gauge of the jack is calibrated against a proving ring. This calibration gives data permitting the supply voltage to be determined for weight intervals of any required magnitude.

Behaviour Under Dynamic Loads

When the weight of a vehicle in motion is measured by the technique described in this paper, errors of weighing might be expected from two main causes :

(1) Overshoot of the galvanometer spot with, possibly, vibration due to vibration of the weighbridge platform on its mounting.

(2) Variation of the effective wheel load of the vehicle due to passage of its wheels over irregularities of the road surface—this might be coupled with rolling and pitching of the vehicle so that the mechanical characteristics of its suspension would affect the wheel load.

To determine the response of the resistance bridge and the optical system to dynamic loads, the ten photo-electric cells of the classifying unit were replaced by a single vacuum type emission photo-electric cell having a large light-sensitive area. This photo-electric cell was connected to a cathode-ray oscillograph on which the deflection of the cathode-ray spot was proportional to the galvanometer deflection. The motion of the oscillograph spot was recorded photographically while a test vehicle, a lorry of common axle type, ran over the weighbridge at various speeds. Fig. 7 shows two of the records obtained in these tests, which were made with the weighbridge platform installed in the eastbound traffic lane of trunk road A.4 outside the Laboratory at Harmondsworth.

The records showed no evidence of overshoot or of vibration of the weighing equipment. In each test, the magnitude of the signal due to the vehicle was compared with a calibration signal produced by switching a standard resistance in parallel with one arm of the resistance bridge. The ratio of the two signals was then taken as a measure of the apparent weight of the vehicle, and, in Fig. 8, such ratios are plotted against the vehicle speed, points being given for both front and rear wheels. An overall increase of 20 per cent occurred for an increase in speed from 0 to 30 m.p.h., but the most striking features are the maxima at 5 and 30 m.p.h. and the minimum at 20 m.p.h. These variations of effective wheel load are probably due to vertical motion of the vehicle arising from its passage over a surface irregularity on the road leading to the platform. The magnitude of the error at any speed probably depends on the amplitude of this vertical motion and its phase at the time when the wheel crosses the weighbridge. The lower part of Fig. 8 shows some of the recorded pulses and the variation of waveform with speed tends to support this explanation.

Many years ago Aughtie, Batson and Brown[2] showed that effective wheel load is increased by the passage of a vehicle over a surface irregularity, and this has been supported by recent measurements of subgrade stress made at the Laboratory. The results obtained with the present apparatus emphasise that every effort must be made to obtain an even surface on the road leading to the platform over a length of, say, 30ft. Measurements must be made at each installation to see whether variations of effective weight with vehicle speed are occurring. The magnitude of the variation of weight and the speeds at which maxima and minima occur may depend on the characteristics of the moving vehicle, making it difficult to make allowance for such variations in the automatic weighing and classifying equipment. Such fluctuations will doubtless occur during the passage of a vehicle along a road and will affect the performance of the construction under traffic.

The variation of the force between a vehicle and the road due to motion of the vehicle on its springs has been studied by Hopkins and Boswell[3] in connection with the U.S. Bureau of Public Roads traffic assessment programme, and the random errors involved in weighing vehicles in motion have been attributed to this motion. The American experience shows neither a systematic increase of error with speed nor the occurrence of maxima and minima.

Zero Drift Due to Temperature Changes

The temperature coefficient of resistance of the foil gauges used in the load cells varied from gauge to gauge even though gauges selected from a single batch were used. In work employing wire resistance strain gauges it is customary to use a strain gauge in each of the four arms of the Wheatstone bridge, as in the present load cells, and this gives adequate temperature compensation. When, however, each gauge varies by a different amount for a given temperature change, additional compensation has to be provided. Accordingly, all four load cells were connected together as shown in Fig. 4, and the whole bridge network was compensated by a pair of coils of copper and constantan wound on a brass former.

When the four load cells and the compensating coils were placed in an oven, the temperature compensation of the whole bridge network was adequate at rates of change of temperature of up to 6 deg. Cent. per hour, which covered the rates of change likely to be experienced on the road. When, however, the load cells were installed in the weighbridge and situated some distance from each other and from the compensating coils, the temperature compensation was inadequate and periodical adjustment of the balance became necessary. Fig. 9 shows the zero drift, expressed in terms of weight reading, which occurred during a period of forty-eight hours at the weighbridge installed on trunk road A.1 at Alconbury Hill, Hunts. The zero drift lagged about two hours behind the temperature change. A positive change of zero resulted from a rise in temperature and caused the weight levels to rise. A rise of 1 deg. Cent. caused a change in level of about 60 lb and the zero had to be adjusted manually when a set of readings was made during a period of one week during January, 1958. When the counters are being read at

two-hourly intervals, there is no difficulty in manual adjustment of the zero, but difficulties arise when the equipment has to be left unattended for periods of, say, a day or a week.

There are obvious advantages in providing automatic correction of zero drift in the

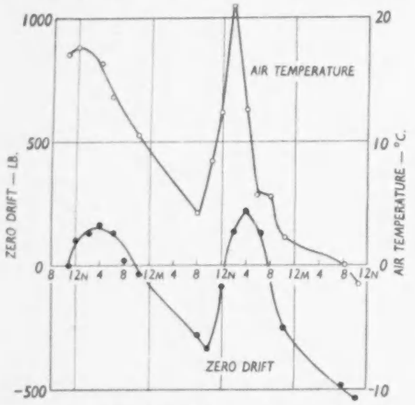


Fig. 9—The zero drift of galvanometer due to inadequate temperature compensation of the resistance bridge

classifying and counting equipment which is transported from site to site. The first of the photo-electric cells shown in Fig. 5—that is, the cell nearest to the zero position of the light beam—has been used for automatically correcting zero drift. Another photo-electric cell has been added at the other end of the set of ten cells for counting the loads of greatest magnitude. The arrangements for zero correction are shown in Fig. 10 and consist essentially of automatically controlling the helical potentiometer to hold the galvanometer light on the first photo-electric cell. When this photo-electric cell is illuminated, the transistor T_2 conducts, a small electric motor is energised, and the potentiometer is rotated in such a manner that the beam of light from the galvanometer is deflected towards zero and off the photo-electric cell. The adjustment is made in the contrary direction when the beam of light moves off the photo-electric cell, and the light is held steady with about half of the photo-electric cell illuminated. The photo-cell T_3 is operated in a " blacked out " condition to control the base bias current of the photo-cell T_1. Since the " dark current " of the photo-cells varies with temperature in a logarithmic manner, T_3 provides a correction circuit which limits the variation of the " dark current " of T_1 with temperature changes, and thus reduces variations in the operating point of the relay RL_1. A clock circuit is included in order that the zero adjustment shall be made for a period of about twenty seconds at intervals of half an hour. This arrangement was devised to prevent the automatic zero adjustment from interfering with the deflection arising from the passage of a vehicle across the weighbridge. The constancy of the zero hold has been checked by continuous recording over a period of twenty-four hours during which a reasonable change of temperature occurred.

Further Experimental Work

The information given in this article shows that the only serious source of error likely to occur in weighing and classifying traffic with the electronic apparatus will arise from the passage of the vehicles over an irregularity just before crossing the weighbridge platform. It is proposed to carry out further experiments to determine the magnitude of the errors and to assess the quality of surface required to minimise them.

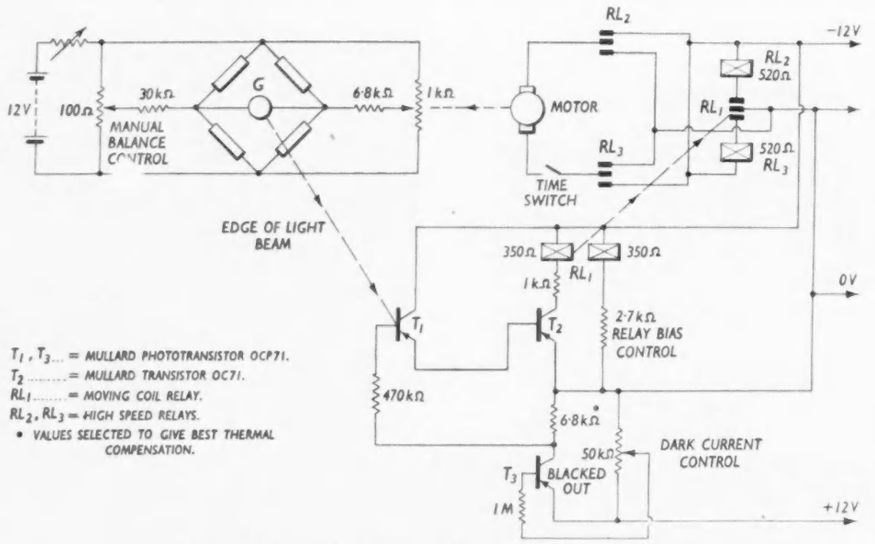


Fig. 10—Circuit of the apparatus for automatic zero adjustment

These will comprise tests at various speeds at Harmondsworth and other available sites using a number of vehicles having different mechanical characteristics, to determine the magnitude of the errors, and if these tests indicate that the errors are appreciable, measurements of the surface irregularity will be made on the approach sections to determine the magnitude of the irregularities causing the trouble. A weighbridge will be installed in a concrete slab with a surface of minimum unevenness and speed tests will be made to determine the length of high quality surface needed to reduce the speed effect to negligible proportions, and also to determine the size of the maximum permissible surface irregularity.

The differences between recorded weight and actual weight arising from increase of vehicle speed are not strictly errors because the weighbridge may faithfully record the force between the vehicle and the road, and it is these forces which will play a part in determining the length of life of experimental road sections. The recorded weights must not, however, be dependent on the nature of the road section near the weighbridge installation, and it is for this reason that experiments are proposed for reducing these errors to a permissible level.

Acknowledgment

The work described in this article was carried out as part of the programme of the Road Research Board of the Department of Scientific and Industrial Research. The article is published by permission of the Director of Road Research.

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Extinction of Running Oil Fires

USE OF WATER SPRAYS

By D. J. RASBASH, Ph.D., B.Sc., A.M.I.Chem.E., and G. W. V. STARK, B.Sc.

Many industrial processes use equipment and pipelines containing flammable liquids, such as oils, which may be at high temperatures. The leakage of such oil could allow fires to develop on metal surfaces. This hazard is particularly important in the electricity generating industry, which uses oil as a medium for cooling transformers, &c., for controlling the speed of turbo-generators, and for lubricating and dissipating heat from their bearings. Little systematic information is available on which the design of water spray systems may be based to deal with this kind of fire. In this note a summary is given of tests on the control and extinction by water sprays of fires involving oil pouring over vertical and horizontal banks of steel tubes. The object of the work was to find how spray properties and fire properties influence extinction and to obtain some quantitative information on which the design of protective installations could be based.

Experimental

An oil fire was established on a bank of twenty-one steel tubes each 7ft long, 2in in diameter, and weighing 21½ lb. The tubes were arranged in three rows of seven at 9in centres and were braced by struts of slotted 1½in steel angle. A thermocouple was inserted in the centre tube to measure a temperature representing that of the tube rig. In most tests the tubes were vertical, but in some the rig was supported on its long end so that the tubes were horizontal. In both cases an oil manifold was used to distribute a flow of oil fairly evenly over the tubes. Fig. 1 shows the vertical rig with a fully developed fire on the tubes. About the rig there was a spray nozzle manifold, from which nozzles could project spray on to the rig in various directions from a distance of 5ft. There was accommodation for up to twelve nozzles to spray downwards and for twelve nozzles to spray inwards at various angles.

Seven different designs of nozzle were chosen to give sprays with a wide range of properties (Table I). With all the nozzles

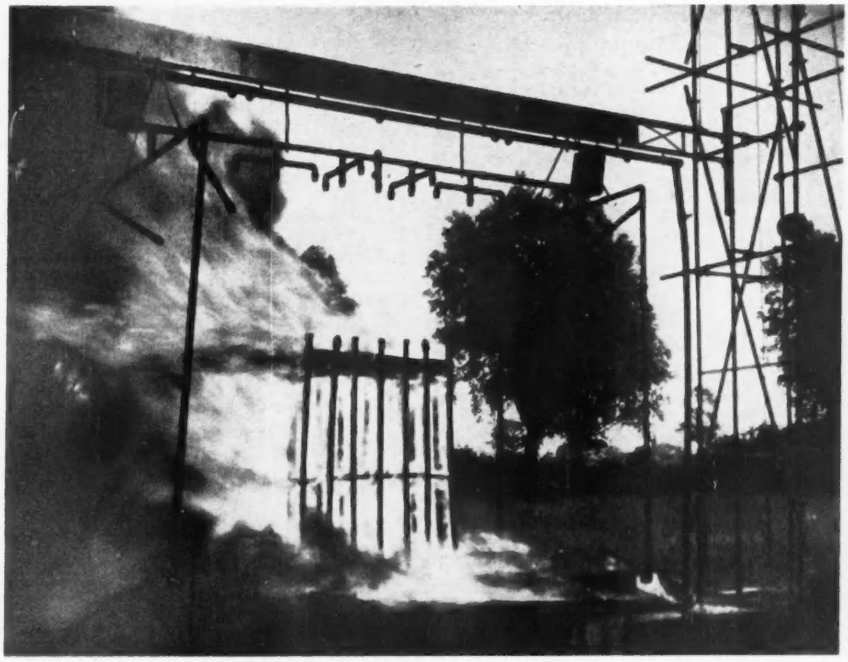

Fig. 1—Fire established on tube rig. Such fires, fed by oil from a suitable manifold, were allowed to burn for a predetermined period before water sprays from the rig visible in the picture began to operate

except one the bulk of the spray was directed forward from the nozzles ; sprays such as these were called "directional." With one nozzle, however, most of the spray was directed outwards ; the spray from this nozzle was called "non-directional." In most tests transformer oil was used at a flow rate of 4½ to 6½ gallons per minute. Other flow rates were tested and experiments were also carried out with kerosine and gas oil. The tube rig was preheated by small petrol fires at the base in a way that ensured that when the oil was turned on, it ignited over the whole rig. After a given time of burning (preburn time) the spray was turned on, and allowed to act on the tube rig for forty-five seconds while keeping the oil flowing.

Results

There was wide scatter in the results, partly because the experiments were conducted outdoors, and several hundred tests were necessary before sufficiently accurate quantitative relationships could be established. Most sprays considerably reduced the overall size of the flames, although the amount of flame associated with the tubes themselves varied considerably with the different sprays. The bulk of the reduction of the flames when spray was applied took place in the first few seconds ; thereafter the change in the size of flames was relatively small.

For a given oil the most important factors governing the control and extinction of the fires were the rate of flow of water reaching the tube rig, and the temperature which had been reached by the tube rig before applying spray. This temperature increased as the preburn time, and also as the oil flow rate increased. There was little difference in efficiency of extinction between sprays from the various directional nozzles, and their performance at a pressure of 90 lb per square inch is summarised in Fig. 2 ; this figure also shows the temperature reached by the metal work after different preburn times. The flow rates shown are the total flow rate of water which reached the rig, divided by the surface area of the envelope that completely enclosed the rig.

As the temperature of the tubes increased, the flow rate required to give control and extinction of the fire increased, the degree of control being defined as the extent to which the tube rig was cleared of flames. As long as all surfaces on which oil was burning were reached by the spray in a reasonably uniform manner, the direction of application of the spray did not have a significant effect on the extinction of the fire, although more rapid cooling of the metal was obtained when the spray axes were at an angle to the metal surfaces than when they were parallel to them. When the rig was surrounded with a shroud of spray, only that part of the spray impinging directly on the rig contributed to the extinction of the fire. Spray reaching the rig from non-directional nozzles was not as efficient as the same amount of spray from directional nozzles. The efficiency of sprays also decreased as the pressure decreased ; this decrease was large between 50 lb and 25 lb per square inch, but between 90 lb and 50 lb per square inch was much less appreciable. A decrease in the fire point of the oil brought about a marked increase in the flow rate required to extinguish the fire.

TABLE I—*Properties of Sprays*
Pressure—50 lb per square inch.

Nozzle type	Swirl		Impinging jet				
	Directional		Directional				Non-directional
Spray pattern	Moderately peaked	Peaked	Peaked	Peaked	Uniform	Uniform	Hollow
Cone angle	65	48	51	100	52	98	140
Flow rate (gallons per minute)	14·0	15·5	28·2	26·3	25·7	24·1	22·4
Nozzle reaction (lb per gallon per minute)	0·325	0·363	0·402	0·336	0·330	0·224	0·105
Mass median drop size (mm)	0·97	0·99	3·2	1·5	1·3	0·68	0·74
Force at obstacle 7ft 6in below nozzle (lb per gallon per minute)	0·51	0·51	0·49	0·44	0·35	0·49	Too small to measure
Force in air current 6ft below nozzle (lb per gallon per minute)	0·240	0·244	0·169	0·156	0·220	0·175	—0·007
Velocity 6ft below nozzle (feet per second)	20·9	26·9	47·8	38·2	25·4	15·9	9·6

N.B.—The measurement of the above properties is the subject of a note in preparation.

Conclusions

It follows that, in protecting with a spray installation a risk similar to the tube rig used in the present experiments, the most important feature must be the direct projection of spray on to the metal surfaces where oil may burn. The flow rate required would depend to a marked extent on the time of burning before spray application and hence on the efficiency of the detecting system. The actual flow rates to be used in any given application would depend on the degree of protection desired. Thus, if control of the fire only were required, considerably smaller flow rates would be necessary than if the installation were expected to bring about rapid and certain extinction.

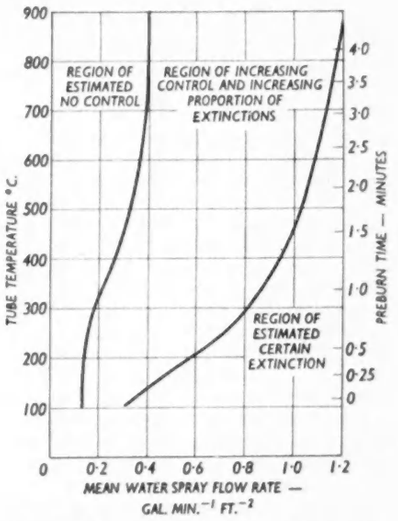

Fig. 2—Control and extinction of oil fires on tube rig (transformer oil, flow rate 5·25 gallons per minute)

In the present tests, when using transformer oil, a flow rate of 1·2 gallon $min^{-1}ft^{-2}$ to the envelope area of the tube rig was found necessary to extinguish the fire reliably and rapidly at all tube temperatures tested (preburn times of up to four minutes). This flow rate may be used as a basic value for the design of protective spray installations for metal equipment containing transformer oil or oil of similar fire point where the requirement is for the installation to give rapid and certain extinction. However, considerably lower flow rates may suffice if it can be assured that the fire will be detected very quickly or if rapid extinction is not a requirement. It may be noted that in the United States, a

flow rate of only 0·25 gal min^{-1} ft^{-2} is recommended to bring about control of fires on electrical transformers[1] but this flow rate is based on tests carried out under less severe conditions than those described above. Much lower flow rates would also suffice for the risk of a pool fire that may be associated with a running oil fire.[2]

Whatever flow rate is employed in the design of an installation, it is important that water spray should obtain access to all surfaces on which oil can burn. For simplicity in design it is possible in many cases to calculate the quantity of water required on the basis of the envelope area of the risk but this should only be done where spray projected to such an area can reach all metal surfaces on which oil is likely to gain access and burn.

Further details of the work on which this article is based are given elsewhere.[3]

ACKNOWLEDGMENT

The work described in this article forms part of the programme of the Joint Fire Research Organisation of the Department of Scientific and Industrial Research and Fire Offices' Committee ; the article is published by permission of the Director of Fire Research.

The authors wish to record their indebtedness to the Building Operational Research Unit of the Building Research Station, on whose site this work was carried out.

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Arc Welding and the Galaxies*

By C. E. R. BRUCE, M.A., D.Sc., M.I.E.E., F.Inst.P.†

Following up an earlier article on electric fields and discharges in cosmic atmospheres, the author shows that his theory has solved a number of additional problems in astrophysics. The main study is of the gas jets which are initiated by electrical discharges, and which, for example, afford, as the E.R.A. has shown, the basic explanation of the arc welding process. They likewise account for observations on the lightning discharge, the gas movements observed in the atmospheres of some variable stars and of cosmic radio-sources. They also explain the origin of the jets of particles from the sun which for the last fifty years have been postulated as the cause of magnetic storms, though their origin has remained a mystery. It is suggested that thermonuclear processes occur in these cosmic electrical discharges when their temperature reaches 400 *million degrees.*

IN an earlier article‡ the writer considered the physical processes involved in the building-up of electric fields in the terrestrial, stellar and galactic atmospheres, as well as some of the characteristics of the electrical discharges which effect the neutralisation of these fields, from the lightning discharge to those which, in the writer's view, result in the formation of the spiral arms of the nebulæ. The theory was shown to be capable of explaining the light emitted during the outbursts of the long-period variable and combination-spectra stars, and to have a bearing on the important questions of their chemical constitution and evolutionary sequence. On the latter questions, the conclusions arrived at differed from those currently held by astrophysicists, but it offered an explanation of the outbursts which is in accord with most of their observed characteristics, where none has hitherto been available.

That article ended with the suggestion that further advances might result from the consideration of these and other astrophysical phenomena from the point of view of their being electrical discharges in cosmic atmospheres. It is the purpose of the present article to show that such further consideration at the E.R.A. has been fruitful, and has enabled the writer to link up the main operative physical process in arc welding with phenomena observed in the lightning discharge and in the atmospheres of the above-mentioned two types of stars, and even in the atmospheres of those galaxies which are acting as radio-sources. The investigation has also led to a new theory of the propagation of these large cosmic discharges, and to an estimate of the temperature in them when thermonuclear processes become of paramount importance. The theory suggests that this occurs at a temperature of about 400 million deg. K. It likewise offers an explanation for the jets of particles from the sun which are postulated as the basis of all theories of magnetic storms, but for which no explanation has so far been put forward.

GAS MOVEMENTS IN ELECTRICAL DISCHARGES

General.—One of the reasons which Franklin gave in the letter, referred to in the first article, explaining how he "came first to think of proposing the experiment of drawing down the lightning," was because the "electrical fluid agrees with lightning" in the "crack or noise in exploding." However, the gas movements which we shall consider have nothing to do with the explosive movement of the surrounding gas due to the sudden increase in temperature in the electrical discharge. The movements to be discussed are continuous jets of hot gas flowing along the axes of the discharge channels themselves.

The Laboratory and Welding Arcs.—The origin of these gas jets can best be understood from a consideration of the laboratory arc discharge. The magnetic field due to the current in the discharge is zero at the centre of the arc and is a maximum somewhere near its periphery. The motion of the charged current-carrying particles in this field causes them to move inwards towards the axis of the discharge. Since they tend to take the gas with them, they cause a pressure rise in these regions, which R. C. Mason showed to be proportional to the product of the current and the current density. This is the now well-known magnetic pinch effect. Maecker drew what is, when someone has at last seen it, the "obvious" conclusion that this pressure rise will increase wherever the discharge channel is constricted, as it is, for example, at the anode and cathode spots of the arc discharge. These, then, besides being points of extra high temperature, are also points where the gas pressure is a maximum. The only way of escape for the gas is along the discharge column itself, since the latter has become a "magnetic hose-pipe," so to describe it, and along this pipe the gas flows out from the two electrode spots, in towards the centre of which it is being continuously gathered from the outer layers, in the manner described. King has pointed out that this inward flow of gas over the electrode surface will gather up molten metal from the one electrode and carry it over to the other, and that this is in all probability the basis of the arc welding process, since there is a decided asymmetry between the conditions at the two electrodes. High-speed cine camera records of the welding arc, taken by Needham (also working in these laboratories), support this view, since the globules of molten metal entrained by these electrode jets are seen to have tails of metal vapour directed towards the electrode, to which the droplets themselves are moving, as illustrated in Fig. 1. These gas jets have nothing at all to do with gravity, so the welding process is also independent of gravity, and depends only on the asymmetry and polarity of the electrode system.

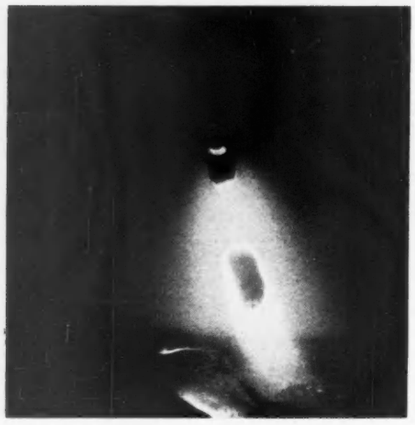


Fig. 1—High-speed photograph of the welding process showing a globule of metal entrained by a welding jet and a "tail" of vapour directed towards the electrode to which the droplet is moving

The Velocity of the Discharge Jets.—The velocity of these jets of gas will be limited by the velocity of sound in the gas at the temperature existing in the central regions of the arc. In the lightning discharge, for example, the current is high, from 5000A or 10,000A up to over 150,000A for periods of the order of 100μsec. to 1 millisecond or more. Under these conditions the axial arc temperature will reach values of the order of 50,000 deg. to 100,000 deg. K., so that the gas velocity will reach values of about 5km to 10km per second. With these durations and velocities material vaporised at the earth's surface will be carried up the lightning channel distances of from ½m to 10m. This explains the observation of Israel and Wurm that metal lines are observed in the spectrum of the lightning discharge up to heights of about 2m above the ground.

The Long-Period Variable Stars.—As in the earlier considerations of the building up of these atmospheric electric fields, the first extra-terrestrial application of these ideas is to the discharges in the atmospheres of the red or long-period variable stars. These are stars with very large diameters at

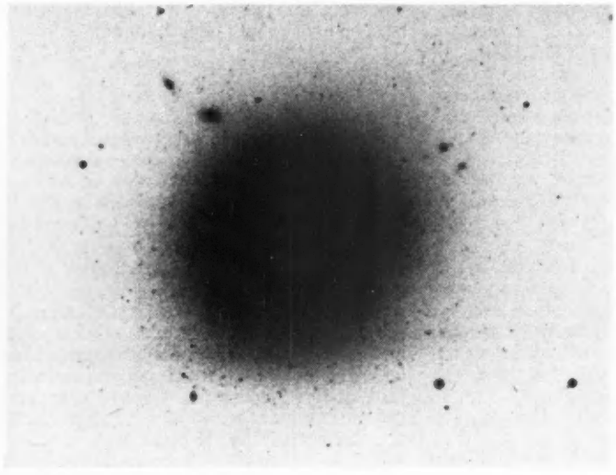
* Based on a series of E.R.A. Reports.

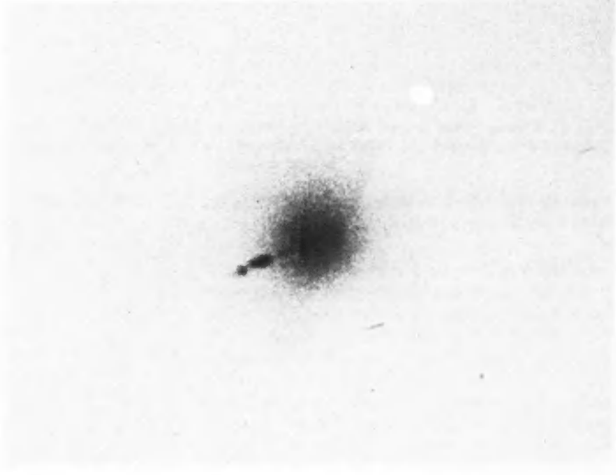
† Electrical Research Association.

‡ THE ENGINEER, August 17, 1956. References to the researches mentioned in the present account will be found in a longer account of this work which will appear in the *Journal of the Franklin Institute*.

temperatures of only 1500 deg. K. or so to 4000 deg. K., and outside these "surfaces" are extensive, presumably colder atmospheres, which could in some stars envelop the whole solar system. Periodical outbursts occur in these stars during which their light changes in a remarkable manner, and their brightness increases in exceptional cases as much as 10,000 times. The only theory capable of explaining the phenomena is the writer's "thunderstorm" theory, which will now enable us to predict the gas velocities likely to be met with in these huge stellar discharges. These predictions can be checked against observation, since the temperature of the gas can be estimated from the lines in its spectrum, and its velocity occurring in the enormous atmosphere surrounding one very large cold star.

Since the velocity of sound in a gas only increases as the square root of the gas temperature, this increase of the gas velocity by a factor of 10 means that in AX Persei the gas temperature must reach 500,000 deg. K. or 1,000,000 deg. K., which was to say the least of it unexpected, in view of the small range of temperatures observed in the long-period variables. However, the existence of these surprisingly high temperatures in the atmosphere of AX Persei has been confirmed by other observers, Swings and Struve, who have found that, during its outbursts, lines appear in its spectrum which could only have come from iron atoms





Figs. 2 and 3—(Left) Radio-source NGC 4486—a globular nebula. (Right) An enlargement of the central regions of NGC 4486. Notice the prominent discharge 300 parsecs long and 30 parsecs wide. One parsec equals 19×10^{12} miles

in the line of sight can be deduced from the shifts of these lines from their normal positions by the Doppler effect.

The bright lines which appear suddenly in the stars' spectra soon after minimum light are those of hydrogen, which is the main constituent of these cosmic atmospheres, and ionised and neutral metal atoms, indicating that the discharge temperatures lie between 5000 deg. and 10,000 deg. K. The velocity of sound in a gas which mainly consists of ionised hydrogen atoms at these temperatures lies between 8·5km and 12km per second. This is an extremely narrow range when one considers that, apart from the theory now put forward, the gas velocity might have been measured in miles per hour, miles per minute, or miles, or tens, or hundreds or thousands of miles per second! Nevertheless the two average values for the gas velocities, which have been observed for two different groups of these stars by the two leading investigators of this type of star at Mount Wilson Observatory are 9km and 11km per second respectively—surely a scientific "bull's eye"!

The theory appeared to receive a rude shock when it was found that Merrill, one of these two observers, had observed a gas velocity of 110km per second in a star of a different, but allied kind, the star AX Persei, a so-called combination-spectra star, because it gives rise to several different types of light. Indeed so varied is the light at different times that it has usually been assumed to originate in a composite source comprising a large cold star, a small hot star, and a nebula, the position of which has not been clear. However, the writer has shown that all the light variations can be explained in terms of electrical discharges which have lost 5, 6 and possibly even 9 electrons, levels of ionisation which require for their production the high temperatures indicated by the "gas velocity thermometer," so to describe it.

Galactic Thermonuclear Reactors

This increase of temperature, as the scale is increased or other conditions of the discharge are changed, cannot go on indefinitely. When a sufficiently high temperature is reached, thermonuclear reactions will be set going, and the rise in pressure they effect will balance the inward pressure due to the magnetic pinch effect. Cosmic gas seems to consist of about 80 per cent hydrogen, including two parts in 10,000 of deuterium, 20 per cent helium, and only fractional percentages of the other elements. The exact physical conditions in these huge discharges is a matter for further investigation, but it is unlikely that appreciable thermonuclear reactions will occur before temperatures of between a hundred- and a thousand-million degrees are reached. On the "gas velocity" thermometer we can therefore predict that the velocities likely to be met with in electrical discharges on a galactic scale will lie between the velocities of sound in ionised atomic hydrogen at these two temperature limits—i.e. between 1700km and 5400km per second.

Just as is observed in the long-period variable stars, the occurrence of these discharges in the atmospheres of the extra-galactic nebulæ will lead to the appearance of emission lines in their spectra. Such spectra have been observed, and have been studied by Seyfert at Mount Wilson. From their spectra he has determined the gas velocities associated with these emission patches in a number of nebulæ. They lie between 1800km and 4250km per second, again in excellent agreement with the predicted values.

Cosmic Radio-Sources

In the original account of these new views the writer suggested that these galactic discharges would occur in globular nebulæ, such as NGC4486, shown in Fig. 2. This nebula is a well-known radio-source, and so was subjected to more intensive scrutiny at Mount Wilson. Careful filtering of its light enabled the enlargement (shown in Fig. 3) of the central regions of Fig. 2, to be obtained. This shows the discharge—300 parsecs long, and about 30 parsecs wide, a parsec being about 19,000,000 million miles.

Shklovsky has explained the emission of this short wave radiation in terms of the movement of "relativistic" or high-speed electrons in a magnetic field. However, the world's astrophysicists recently in session in the U.S.A., were unable to offer any explanation for the existence of either of these two fundamental requirements. On the discharge theory the current in the discharge obviously supplies the main need, that of the magnetic field. As regards the other, if, as has just been seen, the hydrogen atoms have velocities of about 4000km per second, then the average velocity of the associated electrons will be approaching 2×10^{10}cm per second, and individual electrons will have even greater velocities. So the theory offers a complete explanation for the existence of cosmic radio-sources.

Fig. 4 shows another well-known radio-source, NGC1275. Baade and Minkowski have found that the gas in the dark channels is moving at a velocity of 3000km per second relative to the less distinct parts of the nebula, and have suggested that it represents a collision between two nebulæ travelling at 5250km and 8250km per second, respectively, in the line of sight. However, the present theory suggests that NGC1275 is another nebula in which the discharge is occurring which forms the spiral arms, and that the gas in the discharge channels has been accelerated to these high velocities by the pressures resulting from the magnetic pinch effect. The latter is probably the only mechanism which can lead to the concentration of the gas and dust along well-defined channels, a distribution of matter which has

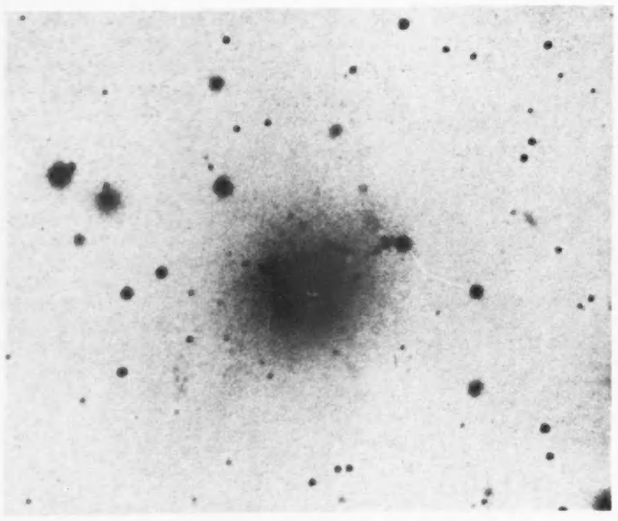


Fig. 4—Another radio source NGC 1275. In what shows here as a "dark" channel, gas velocities of 3000km per second have been observed relative to the rest

been shown to exist in our own galaxy by both optical and radio observations.

Propagation of Cosmic Discharges

The considerations in the preceding sections have led to a new theory of propagation of these large cosmic electrical discharges. The velocity of propagation should be independent of the gas density, even over the wide range of density—10^{20} to 1—considered herein, since it depends on the product of the breakdown voltage, which is directly, and the mean free path of the particles, which is inversely, proportional to the density. This would mean that the velocity of propagation should be less than 500km per second, even in hydrogen, the velocity of the lightning leader stroke in air being about 200km per second.

However, as the temperature of the gas increases in the discharge column already formed, the velocity of the jet of gas generated inside it will also increase, and when it exceeds about 500km per second, then it will overtake the advancing tip of the discharge, and thereafter the propagation will be by the jet. This will occur at a discharge temperature of about 8,000,000 deg. K. From what has been said, this will be seen to lead to an upper limit of about 4000km per second for the velocity of propagation of these cosmic discharges.

Magnetic Storms

These considerations may also clear up an outstanding difficulty—or rather, several outstanding difficulties—met with in endeavours to account for those magnetic storms which follow outbursts at the sun's surface by intervals of one to four days. The writer suggested that these are the result of electrical discharges propagated out from the sun past the earth, but the high average velocities, of the order of 2000km per second, were difficult to explain, even on this basis. Indeed, the situation had become even more puzzling as a result of Meinel's observation that in magnetic storms and the associated auroræ, hydrogen atoms actually enter the earth's upper atmosphere at velocities of up to 3500km per second. There thus seemed to be no doubt that the storms were due to jets of particles passing the earth, and such postulated jets have been the basis of all earlier theories, though no satisfactory solution had hitherto been offered to account for the jets. Another apparently insuperable difficulty had been met in efforts to explain how these jets were able to come out as jets through the relatively dense solar corona. As the highest velocities so far observed at or near the sun's surface are in the region of 600km or 700km per second, they not only can get out, but in their progress to the earth are accelerated to average velocities of 2000km per second and to 3500km per second by the time they reach the earth.

However, as will be evident, the discharge theory now has an explanation to offer for all these strange observations. The jet of particles is, on that theory, the result of the magnetic pinch effect, in a solar atmospheric discharge, and the increase in velocity *en route* from sun to earth is the result of an increase in the discharge temperature as it is propagated out through the relatively rapid density gradient in the sun's atmosphere, until temperatures of the order of 400 million deg. K. are reached in the earth's vicinity. As temperatures of the order of 5,000,000 deg. K. are already reached in the solar corona, and temperatures of the order of 1,000,000 deg. K. have already been attained in the laboratory, this deduction from theory need not surprise us too much.

At least we can point to a similar increase in temperature when electrical discharges are propagated down the much less steep density gradients in some stellar atmospheres. For example, in the discharges in the combination-spectra stars referred to earlier, the spectrum at the initiation of the discharge contains lines of *H* and of neutral and singly-ionised metal atoms, indicating discharge temperatures of between 5000 deg. and 10,000 deg. K. However, after periods of the order of 100 to 200 days, lines of nine times and even thirteen times ionised iron atoms are observed in their spectra, showing that as the discharge reaches the low densities of the peripheral regions of the star's atmospheres, its temperature has reached millions of degrees. This is not surprising, for it may be recalled that in the first article the writer pointed out that these long atmospheric electrical discharges act as energy pumps, liberating in regions of low density energy built up in regions of high gas density.

Discussion

In the first general account of these ideas published in 1944, the writer emphasised that the great advantage of this new conception of the build-up and breakdown of electrostatic fields in cosmic atmospheres is that it enables a great number of astrophysical observations to be strung on one theoretical thread, so to speak. The discoveries of the intervening years have made this aspect still more attractive. For example, separate postulates of the existence of galactic magnetic fields and relativistic electrons, have been put forward to account for galactic radio-sources, unless one prefers the suggestion offered by two leading astrophysicists to account for the "jet" in NGC 4486, shown in Fig. 2, in this passage in a leading American journal: "Astrophysicists have been at a loss to account for its extremely strong radiation, and it is tempting to suppose that the energy is coming from the galaxy's capture of a gob of anti-matter from an anti-galaxy." In this, as in other fields, some are more easily tempted than others, but the nature of the suggestion underlines the difficulties which these new observations present to existing astrophysical theories.

Apart from the discharge theory, there are similarly no explanations available for the extremely high temperatures in the sun's corona and the gas jets in its atmosphere, nor for the excitation and gas movements in the atmospheres of the two kinds of stars discussed or of the extra-galactic nebulæ. Whereas these are at present merely a series of disconnected and inexplicable observations, they can all be satisfactorily correlated by the electrical discharge theory, with satisfactory numerical agreements between theory and observation over the whole range.

SHORTER REPORTS

Refuelling Ships at Sea

THE advent of the steam era, despite its many advantages, had a severe limitation imposed by the capacity of coal bunkers, and warships had to return periodically for loading more coal. When oil fuel had succeeded coal, the situation was that an oil-burning vessel could be fuelled on active service while at sea—provided that suitable hose equipment was available. Accordingly, The Goodyear Tyre and Rubber Company (Great Britain), Ltd., was requested by the Admiralty to study a specification based on operational requirements and to develop a hose for this duty. The design finally agreed upon was a hose of 5in bore with a square woven cotton reinforcement. It was made up in 60ft lengths which were supported by a jackstay slung between the supply vessel and the warship being refuelled. Special externally wire-armoured end connections, 15ft long, were also used.

After the war, the company was asked to develop a hose with increased strength, high rates of flow, and which would withstand shock loadings, and a design was produced to meet these demands. Later, the company co-operated with the Admiralty on a development programme based on experience under wartime operating conditions. In 1948 new designs in 30ft lengths were put on sea trials and by 1950 a 6in bore hose with rayon reinforcement had been standardised.

The use of high-strength rayon resulted in a hose that could be used for the new method of astern fuelling without the use of jackstays. It could withstand the additional stresses involved and, furthermore, would float when filled with the furnace oil which it was to transfer from the tanker to the warship. A ship could now come astern of the supply vessel and take on board the free end of the floating hose trailing astern of the tanker. Station keeping was not now so critical as it was for the previous method of fuelling abeam, an especially difficult operation in bad weather.

Concurrent with the development of the new hose, attention was also given to couplings, and for the new hose a new coupling was designed which was vulcanised into the hose during manufacture. This combination of hose and coupling was in general use until late in 1956, by which time a further design with improved characteristics had been developed and tested in service.

The hose with rayon reinforcement could deliver 400 tons of fuel an hour when used abeam, but its capacity was much reduced when used astern. This hose could withstand the considerable loads imposed by astern fuelling, but in doing so was elongated, thus causing a reduction in bore which reduced the capacity of the hose. It also meant that the hose was considerably greater in outside diameter at the couplings and inequality in diameter led to difficulties when bringing the hose back on board the tanker.

Consequently, investigation into a hose with improved characteristics when used astern, was initiated at the request of the Admiralty towards the end of 1953. Two new designs were prepared, and tests ashore, followed by extensive sea trials, were completed during the next three years. Both the new designs were 6in bore hoses with "Terylene" reinforcement and built-in light alloy fittings. After sea trials and operational experience had confirmed the satisfactory test performances, a decision was made in favour of the lighter construction of the two.

Here was a hose which would give higher rates of flow when used astern, was easily handled, would float when filled with air at 5 lb per square inch (or the fuel it was to carry), and had the strength required to withstand all the severity of an exacting duty.

Now there are four types of Goodyear refuelling hose in use by the Admiralty. The rayon construction continues to be used abeam, while the "Terylene" hose is used astern. Both constructions are made with alternative compounding, one for handling furnace oil and the other for high-octane fuels for carrier-borne aircraft. All four types are fitted with light alloy couplings, vulcanised into the hose during manufacture.

Delhi Engineering College

THE Delhi Engineering College Trust has been established to provide buildings, staff and equipment for the new Delhi College of Engineering and Technology, the foundation stone of which was laid by H.R.H. The Duke of Edinburgh on January 27, this year. The Indian Government is spending £1,000,000 on buildings and H.M. Government is spending £250,000 on British staff from Colombo Plan funds. H.M. Government is to provide ten British professors who will design the syllabuses in consultation with the Indian education authorities. Requirements in advanced training aids will be met by purchases from British producers of such equipment.

In co-operation with the Institutions of Civil, Mechanical, Electrical and Chemical Engineers, British industry has set up a trust to administer a sum of at least £250,000, to be subscribed by members of the Federation of British Industries and other British companies, to provide equipment for the College. Commenting on why British industry was contributing to the project, H.R.H. The Duke of Edinburgh pointed out that engineers and technologists were greatly needed in India, and that this was an example of friendly co-operation between two Commonwealth Governments. The raising by British industry of a fund for equipment was a measure of the interest of independent companies in the United Kingdom in the technical progress of India.

The appeal was originally launched by Sir Hugh Beaver, when he was president of the Federation of British Industries, and Mr. W. H. McFadzean, on succeeding him as president of the Federation, has also succeeded him as chairman of the Trust. His appeal, now published, for £70,000 which is still needed, asks companies interested in contributing to this project to write to Sir Eric Coates, chairman of the Executive Committee of the Trust, at Bowater House, Knightsbridge, London, S.W.1. The names of British companies contributing will be listed in a permanent record in the Delhi College.

Birmingham-Lancaster Motorway

THE proposed lines of two further sections of the Birmingham–Lancaster Motorway totalling 43 miles have been published. These lines, with those already fixed, are intended to establish the route of the whole 141-mile motorway.

The first proposal is for 13 miles of motorway to link the 12-mile Lancaster By-pass, due to be finished next May, with the Preston By-pass which was completed in November, 1958. This new section will run east of the A.6 and the railway line between Preston and Lancaster, and will have no intermediate junctions with any other roads. South of the Preston By-pass, the line of 78 miles of motorway, ending at Dunston to the south of Stafford, was statutorily fixed in June, 1958, and work has already started on some of the bridges.

The second proposal extends the motorway some 30 miles southwards and eastwards from Dunston passing between Wolverhampton, West Bromwich and Birmingham on the west and Walsall and Sutton Coldfield on the east, then swinging eastwards to follow the line of the Tame Valley Canal to within 2½ miles of the centre of Birmingham. Extensive bridging of canals, roads, rivers and railways will be required. For about 7 miles on this section the road will be an urban motorway in character.

After passing north of Castle Bromwich the road turns south-eastwards to join A.446 south of Coleshill. From this point traffic will be able to connect with the London–Birmingham Motorway at Dunchurch by using A.446 and A.452, which are to be provided with dual carriageways in the future, and A.45 which already has dual carriageways as far as Dunchurch. In the whole length of 30 miles there will be eight two-level junctions with existing trunk roads.

Details of the proposed lines will be on view for the next three months at the offices of appropriate local authorities. During that time any person may make representations to the Minister of Transport or lodge objections to the making of the schemes. Proposals for linking the Bristol–Birmingham and Birmingham-Lancaster motorways, and for extending the latter from Coleshill to join M.1, are now being prepared.

National Research Development Corporation

THE tenth annual report of the National Research Development Corporation just published shows that during the year ended June 30 last, nearly 700 inventions were communicated to the Corporation and some 200 patent rights were assigned to it. At the end of the year under review, the Corporation held rights in nearly 2800 patents or patent applications; of these 1038 were being actively exploited and 395 licences were in force with manufacturers. During the year the Corporation spent £929,210 (which brought the cumulative expenditure over the ten years since starting up to £3,559,000) and its total income for the twelve months was just over £285,900.

Nine new projects were initiated or reported upon during the year and they included: Bush chromatographic equipment; Cephalosporin; Professor Cherry's television compression system; Professor Ford's rolling mill, which uses rolls supported in hydrostatic bearings; Mr. C. S. Cockerell's "Hovercraft"; a leather continuous processing equipment; the N.I.A.E. ditch cleaner; an N.P.L. pitch stabiliser for ships; and a pharmacological screening project.

Notes are given in the report of the work in progress on a number of development projects initiated in previous years. In connection with a process for producing acetylene by partial combustion of methane, promising results have been achieved and preliminary discussions have been held with manufacturers for commercial exploitation. In electronic digital computers it has been decided to support the development of two substantially different computers of advanced design and high speed. A project concerned with the use of an electronic data processing system for production planning and engineering stores control is expected to be completed shortly.

A second detailed design study has been completed with the Fanshaw oil well drilling rig and its exploitation is now being discussed with interested manufacturers. In connection with financial support given to a small independent enterprise engaged on developing and making printed circuits, development was completed and the firm is now carrying on a profitable business. Frequent reference has already been made in the press to some of the other development projects in hand, including the hydrogen-oxygen fuel cell; the "Dracone" flexible containers used for the transport of oil at sea; the variable speed induction motors of Professor Williams; the report lists several other projects of interest in progress.

Of the Corporation's total income of £285,900 for the year, more than £180,000 was received from royalties on inventions which have been licensed to industry. Nineteen inventions which were responsible for the bulk of this income are listed in the report.

British Machine Tool Industry

It has been announced that the Machine Tool Trades Association and the Department of Scientific and Industrial Research are continuing their discussions of the action to be taken as a result of the D.S.I.R. survey of the research and development requirements of the British machine tool industry. A further meeting, concerned mainly with education and research, was held on December 8, 1959, with representatives of the Ministry of Education.

On education, the representatives of the industry concurred with the view of the Ministry of Education that the existing education and training facilities for students proceeding beyond Higher National Certificate level could be more fully used, but that more specialised courses were also necessary. There was a need both for more students and more teachers. The representatives of the Ministry of Education invited the industry to assist in reviewing the curricula.

On research, the meeting noted that D.S.I.R. grants for research in the field of machine tool technology had already been made to two universities and that others were under consideration. It was also noted that exchanges of visits between research engineers from the National Engineering Laboratory and engineers from machine tool firms had taken place. More visits were being planned.

While appreciating the advantages of making more use of existing facilities for research, the representatives of the industry undertook to give further consideration to the kind of research organisation most suitable to the needs of the industry. It was agreed that there was a need for much closer co-operation between engineers and designers in industry, on the one hand, and the research work of universities, colleges and research institutions on the other.

Corrosion Inhibition

Liquid-cooled engines are particularly prone to corrosion in climates which are cold enough to occasion the use of anti-freeze additions to the coolant, and an inhibitor is particularly necessary where ethylene glycol is used in high temperature systems. The use of borax as an inhibitor, long established in the United States of America, is now spreading in Europe, and Borax Consolidated, Ltd., Carlisle Place, London, S.W.1, has issued some details of investigations into the performance of borax using English anti-freeze mixtures as controls.

The mechanism of protection by borax is anodic inhibition. A series of accurate determinations of pH for mixtures of ethylene glycol containing 3 per cent borax and water showed that the pH value was above 7 for all mixtures weaker than the 60 : 40 eutectics ; because of the buffering capacity of borax the pH is very stable. Field tests were performed by placing within the cooling systems of a number of vehicles clusters of samples, each cluster including a piece of cast iron cut from a typical engine casting and a sample of aluminium alloy to either LM.6 or LM.14 of B.S.S. 1490 : 1955 (Borax is not expected to protect pure aluminium.) The anti-freeze preparations used were ethylene glycol (to B.S. 2537 : 1955 and found to contain less than one part per 1,000,000 chloride) inhibited with 3 per cent borax decahydrate, ethylene glycol to D.T.D. 779, and ethylene glycol inhibited to D.S.I.R. formulation. These solutions were mixed with four volumes of tap water containing, on average, 30 p.p.m. of NaCl. All three coolants protected LM.14 distinctly better than LM.6, and it is considered that LM.14 is perfectly safe with ethylene glycol containing 3 per cent borax. In these tests the cast iron sample suffered severely, although less in borax solutions, and it is considered that the test may have been unrepresentative, in particular in that the samples were close to the surface of the coolant, where oxygen concentration might be higher.

Borax Consolidated offers two sodium tetraborate compounds, borax decahydrate, $Na_2B_4O_7.10H_2O$, and pentahydrate borax, $Na_2B_4O_7.5H_2O$; the latter, sold as "Neobor," is strictly equivalent to the former at a ratio of 76·4 parts by weight to 100—when transportation, handling and storage costs are large, the more concentrated salt may be more economic. Solubilities are as follows, by weight :

Solvent	Borax, per cent	"Neobor," per cent
Ethylene Glycol	41·6	31·1
Methanol	19·3	11·7
Water	5·9	4·5

It is observed that the anodic film stable in the presence of borax is not sustained when in contact with ordinary water, so that corrosion may occur after the glycol or methanol had been discarded. Since only 3 per cent of borax is undiluted ethylene glycol is adequate, the solubility of borax in water should be adequate to meet this case.

It will be recalled that there exists a British Standard for anti-freeze solutions based on ethylene glycol and inhibited with borax, B.S. 3152.

(Reply Card No. 8682)

New Canadian Microwave Link

A new microwave link between Moncton and St. John, in New Brunswick, Canada, operating in the 2000 Mc/s band, was commissioned on December 12. At present the link is carrying sixty speech circuits, but it has a capacity of 240 circuits and may be switched to transmit television signals if required. Work is already in progress to extend the link from Moncton to Campbellton, and from St. John to Halifax and Sydney. The equipment is manufactured by The General Electric Company, Ltd., of England, and installed by the Canadian General Electric Company for the New Brunswick Telephone Company and the Maritime Telegraph and Telephone Company. It incorporates built-in metering facilities, and the equipment panels have plug-in connections to the permanent rack wiring for easy installation and replacement. In connection with the television facilities, it may be recalled that the first microwave link in the United Kingdom to carry television signals was manufactured and installed by the G.E.C. between London and Birmingham ten years ago. The original equipment operated in the 900 Mc/s band, but the capacity of the link has since been increased by further channels in the 2000 Mc/s band.

Foundry Apprentice Training

In May last a study conference on the subject of foundry apprentice training was held under the auspices of the training committee of the Council of Ironfoundry Associations, and a report of this conference has now been circulated to iron foundries in the United Kingdom. An important outcome of the conference was a recommendation that there should be a suitable form of recognition of foundry craft skill, and to this end a certificate of minimum practical skill should be introduced for issue to foundry apprentices at the end of their apprenticeship. This certificate would be issued by companies or groups with an approved training scheme to their own apprentices. Other foundries would be entitled to submit apprentices for an independent practical test for the award of certificates, and equivalent certificates could be issued to boys at the successful completion of a full course at the National Foundry Craft Training Centre.

It was considered that modern developments tended to increase both the number and importance of technicians and that their training needs might be considered at a similar conference. In this connection it is of interest to note that as a result of this proposal a working party recently considered the training of foundry technicians, and its recommendations are to be discussed in the coming year.

Light Alloy Landing Craft

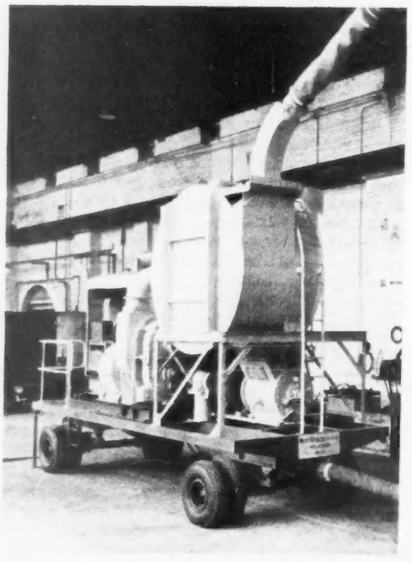
A ramped landing craft, for service overseas, has recently been completed by the Fairmile Construction Company, Ltd., Cobham, for the Air Ministry, and will be used for ferrying a 14½-ton refuelling road tanker between ship and shore. Aluminium alloys to B.S. NP5/6 specification for plate and NE5 section for sections, supplied by the Northern Aluminium Company, Ltd., were used for the construction of the landing craft which has a hull which is basically a water-tight box, with the side plating carried up to form a coaming. The length is 50ft 4in, the breadth 14ft, and the depth moulded 6ft, while the effective length of vehicle deck is 30ft. The mean draught unladen is 1ft 8½in and the loaded draught is 2ft 6in. Since the landing craft has to be lifted on board its parent ship, the maximum lifting weight was specified as 15 tons; however, by adopting light alloy construction, the weight was well within this limit, at 11½ tons. The deck is partly timbered, to provide a track for the vehicle, as is also the loading ramp. Propulsion is by means of two Perkins mark S.6.M. diesel engines, each of 100 h.p. and driving a chromium-plated propeller through a 2 to 1 reduction/reverse gearbox.

[Reply Card No. E8685]

Mobile Pneumatic Handling Plant

A mobile pneumatic handling plant with a capacity of 50 tons an hour has been designed and built by Spencer (Melksham), Ltd., Melksham, Wilts, for handling wheat and similar materials. This capacity is possible when the intake nozzle is sinking vertically into free flowing material and using an intake pipe 100ft long with a vertical direct lift of 50ft and having one bend. The delivery pipe for this condition can be 100ft long laid horizontally with not more than one bend in it.

As can be seen in the illustration below, the equipment is mounted on a fabricated steel



Receiver end of mobile pneumatic handling plant of 50 tons per hour capacity

section chassis fitted with pneumatic tyred wheels, the overall weight being 13½ tons. It can be powered by a diesel engine or by an electric motor if a mains supply is available. The engine drives a Roots exhauster through vee belts. A grain receiver of normal cylindrical design is mounted on its side with the grain inlet set at the highest point. The grain enters the receiver tangentially so that separation of the larger dust particles is facilitated.

The discharger below the receiver provides the air seal necessary to maintain the partial vacuum within the system while allowing material to pass through to the blowing chamber leading to the delive rypipe below. Separate inlets are provided in this discharger for the main grain stream from the receiver and for dust from the internal cyclones. A slipping clutch through which the discharger is driven prevents damage should a foreign body become jammed between its rotor and the casing.

A cyclone built into the side of the receiver delivers dust into the discharger. To prevent material being drawn over into the exhauster an air receiver containing a fine mesh grid is fitted in the pipeline from the cyclone.

[Reply Card No. E8686]

Powdered Freight Handling Equipment

To facilitate the discharge of powdered materials carried in bulk in special wagons on British Railways a portable aeration equipment has been developed by Thomson and Taylor (Brooklands), Ltd., Byfleet, Surrey, working in conjunction with the British Transport Commission. These powdered materials, such as cement, when carried in bulk consolidate during transit as a result of vibration and the new equipment is designed to deliver pressure air through a porous diaphragm at the discharge position in the base of the wagon. The air passing through the powder builds up a pressure in the cavity above the load and when a predetermined pressure is attained discharge begins. The continuation of aeration at the discharge point combined with the pressure in the container above the load gives a smooth discharge.

One of the new discharge equipments can be seen in the accompanying illustration. Each set is mounted on a channel section frame carried on pneumatic wheels and incorporates a diesel engine driving a Wellworthy-Ricardo positive displacement or a Wade Roots design air compressor. The Wellworthy unit has fourteen double-acting pistons disposed in two banks of seven grouped axially around two rotary valves. The Wade unit comprises a conventional three-lobe Roots blower arranged in either single- or two-stage layouts. Air is supplied to the compressors through Vokes "Micro Vee" air cleaners and on the delivery side it passes through a non-return valve, before being piped to the wagon through 2½in diameter armoured hose. A spring relief valve fitted is set to control the operating pressure at 10 lb per square inch on single-stage sets and 19 lb per square inch on the Wade two-stage sets.

A vertical, two-cylinder, four-stroke, cold-starting, direct injection air-cooled oil engine used for the drive is arranged to develop 20 b.h.p. at 1500 r.p.m. for a Wellworthy compressor, and 22 b.h.p. at 1800 r.p.m. for the single-stage Wade set. For driving the Wade compressor either a Petter P.D.2 or an Armstrong Siddeley 14/22 engine can be supplied. In the case of the Wade two-stage compressor, a Petter four-cylinder engine rated at 48 b.h.p. at 1800 r.p.m. is used.

It is stated that under average working conditions one of these blowing sets can clear a "Presflo" wagon into a road vehicle at the rate of 1 ton of cement per minute, or where a trackside silo is to be filled cement can be blown to a height of 40ft–50ft at the rate of 1 ton per minute, working at 19 lb per square inch approximately. Developments are in progress for producing larger blowing sets capable of unloading more than one wagon at a time to meet the rising demand for this method of bulk handling. Other materials for which this handling system is at present suitable, or being considered, are salt, flour, alumina, fuller's earth, powdered lime, pulverised fuel, slate dust and basic slag.

[Reply Card No. E8691]

Mobile Tower Cranes

RECENT additions to the Coles range of diesel electric cranes, made by Steels Engineering Products, Ltd., Sunderland, are three mobile tower cranes with respective lifting capacities of 2½ tons at 25ft radius, 3 tons at 30ft radius and 5 tons at 30ft radius. When fitted with standard 30ft centres strut jibs each of these cranes can raise loads to a height of 43ft. The three cranes are basically of similar design with a fabricated steel-tube tower structure mounted on the crane superstructure and housing the jib pivot situated approximately 20ft above ground level. This design allows the cranes to be used for duties outside the scope of normal strut jib cranes. The driver's cab is placed at the top right of the tower some 30ft above ground level, giving an unrestricted view of the whole working area.

In each crane the design incorporates means for raising and lowering the tower structure to permit travel under bridges and overhead wires or, when possible, they can be driven and manœuvred with the tower erected, as shown in the illustration. These machines can be used as either a strut jib crane or a mobile tower crane, and their conversion from one form to the other is stated to take less than one hour.

As on many other models in the Coles range of cranes, the power unit comprises a diesel engine mounted on the superstructure and coupled to a variable voltage generator which supplies current to the separate motors of the hoist, derrick, slew and travel motions. Each motion is controlled by an interlocked pair of heavy-duty reversing contactors which are operated by pilot switches located on a console in the driver's cab. The normal driving routine is to engage the pilot switch for the motion or motions desired while the engine is running at reduced speed, and thereafter speed of motion is controlled by varying the engine speed through the accelerator.

Several integral safety measures on these cranes are designed to protect the operator, load and machine. Automatic limit switches protect the machine and load should attempts be made to hoist or derrick beyond the permitted limits. Electromechanical brakes are automatically applied to hoist, derrick and slew motions should the supply of current be interrupted either accidentally or intentionally. A safe load indicator fitted gives the operator both audible and visual warning should attempts be made to lift loads beyond the capacity of the machine, and this equipment automatically cuts the circuits of the hoist and derrick motions at a predetermined overload.

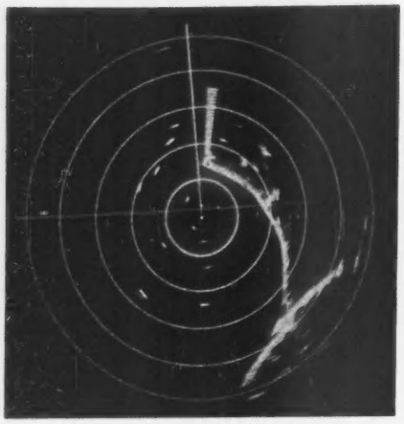
[Reply Card No. E8692]

Mobile tower crane, with a lifting capacity of 2½ tons at 25ft radius, which can be converted into a conventional strut-jib crane in about an hour

A 10-ton bulk cement vehicle being loaded from a "Presflo" wagon using a portable aeration equipment

Radar Beacon Experiment at Dungeness

A RESPONDER beacon designed to assist ships' radar operators to distinguish between a navigational position (such as a light vessel) and other targets in the vicinity has been manufactured to a Trinity House specification by Kelvin and Hughes (Marine), Ltd., Kelvin House, Wembley Park Drive, Wembley, Middlesex. The new beacon, designated "Racon," has been installed initially for technical evaluation at Dungeness, and will be fitted eventually to the Bar Light Vessel in the Mersey for operational evaluation. We reproduce a P.P.I. photograph showing the form taken by the "Racon" signal. This normally consists of fifteen to twenty "blips" beginning slightly beyond the position on the tube of the "Racon" itself and extending outwardly on the line of bearing of the "Racon" from the interrogating ship over a range of 4 miles. The small gap between the beacon position and the beginning of its signal is caused by the interval between reception of the interrogating pulse and transmission of the answer. When the "Racon" is installed on the Bar Light Vessel the ship itself will give a recognisable echo which will be identified by the associated "Racon"



Typical response of "Racon" beacon, seen at a range of 3 miles

response. It will then be possible to determine the separation between them and to judge whether any ambiguity could exist.

The technical and operational evaluation tests will also provide information on the useful range of the beacon. Vessels at distances greater than 15 to 20 miles are unlikely to pick it up. It is not expected that any difficulties will arise from saturation of the beacon by interrogating pulses, since for this to occur all interrogations would have to be on the same frequency, all pulses would have to be triggered simultaneously, and all ships' aerials would have to be "looking at" the beacon aerial on the same line of bearing.

In order to cater for the slightly differing frequencies of different radar sets, the "Racon" is swept over the radar frequency band once in every seventy-five seconds. Furthermore, the "Racon" will only be operational for every alternate five minutes, beginning on the hour. The signal will therefore only be seen every seventy-five seconds during alternate five minute "on" periods. No special equipment is required other than the normal ship's radar and no adjustments are required by the operator.

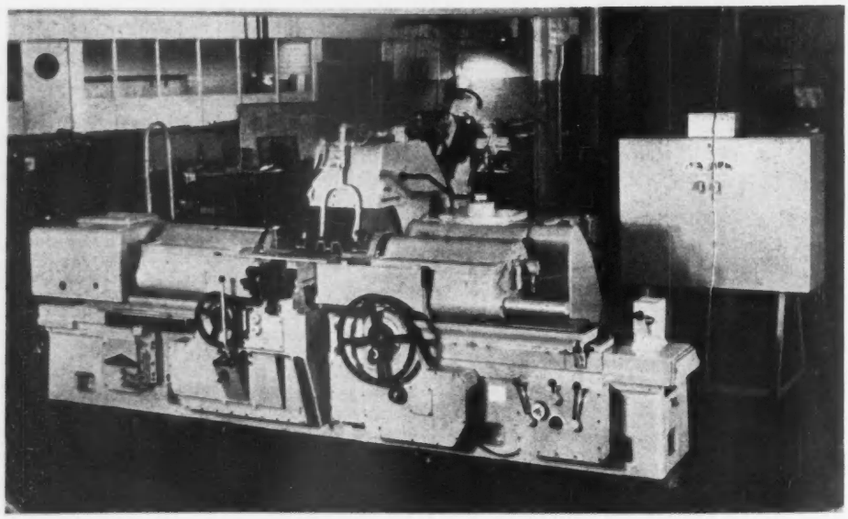
[Reply Card No. E8693]

Crankpin Grinding Machine

A HEAVY-DUTY automatic crankpin grinding machine has been introduced by Newall Group Sales, Ltd., Old Fletton, Peterborough, for the high-speed production of small and medium-sized four- or six-cylinder crankshafts. On this Newall-Keighley machine, to be seen in the illustration below, two in-line pins are ground simultaneously in one cycle. The machine has a work centre height of 10in and the distance between the faces of the workhead and tailstock spindles is adjustable between 24in and 48in. It is equipped with two quick-approach and synchronised automatic hydraulic steadies with centres adjustable between 2¼in and 12in. The grinding wheels of 42in maximum diameter which can be fitted can be set with a maximum distance of 12½in over their outside edges. All controls on the machine are interlocked and, after initial setting up, a complete operating cycle can be controlled by movement of a single joystick lever.

The wheelhead is driven by a 20 h.p., 1000 r.p.m. motor and is mounted on widely-spaced vee and flat ways. It has a rapid approach and withdrawal movement of 5in and four rates of automatic variable infeed, one for face and three for diameter grinding. The heavy-duty workheads are rotated at 70 r.p.m. by a large diameter shaft driven through vee-belts by a 3 h.p. constant speed motor, drive from the shaft to the work spindles being transmitted by inverted-tooth chains. An electric brake in the drives is designed to stop the work rotating when the holding fixture is in the unloading position. A hydraulically-operated wheelhead-mounted dresser for truing wheel peripheries which can be supplied incorporates twin diamond holders, each with means of micrometer adjustment. The dresser controls for setting purposes, which are mounted on the front of the machine, include a dial calibrated in increments representing a reduction in diameter on both wheels of 0·001in. The actual dressing operation consists of one pass with cut applied and return movement with no additional feed; this operation is automatically brought into effect when the wheelhead retracts at the end of each grinding cycle and is associated with automatic compensation for wheel truing.

[Reply Card No. E8701]

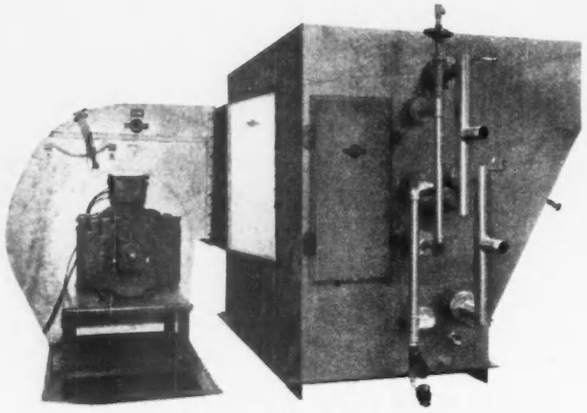


Heavy-duty automatic-cycle crankpin grinding machine on which two in-line pins are ground simultaneously

Air Conditioning for Ships

THE firm of Carrier Engineering, Ltd., recently announced the production of a new design of air conditioning for ships which has been extended to give full air conditioning in cabins with individual automatic control. All the equipment has been designed from first principles and incorporates all those qualities required of equipment on board ship, such as compactness, robustness, accessibility and ease of maintenance. The system employs higher velocities than used hitherto so that the space required for trunking is reduced and there is greater economy in operation.

The equipment consists of a central station air conditioning plant using the "push through" method and individually controlled terminal units for supplying cabins or passageways. We illustrate a central station air conditioning plant having a capacity of 6500 cubic feet per minute.



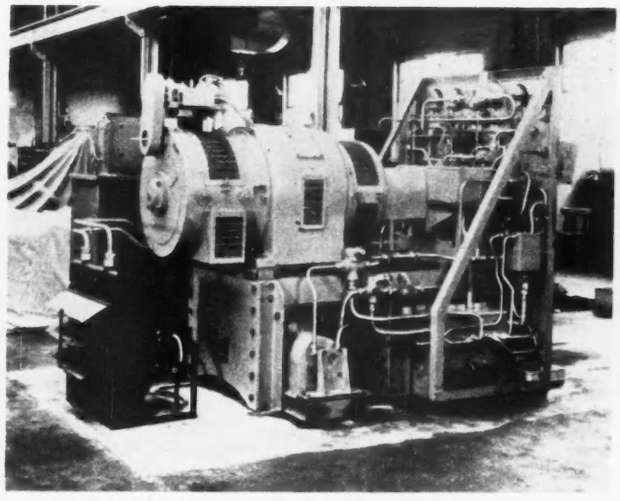
Central station air conditioning plant of 6500 cubic feet per minute capacity

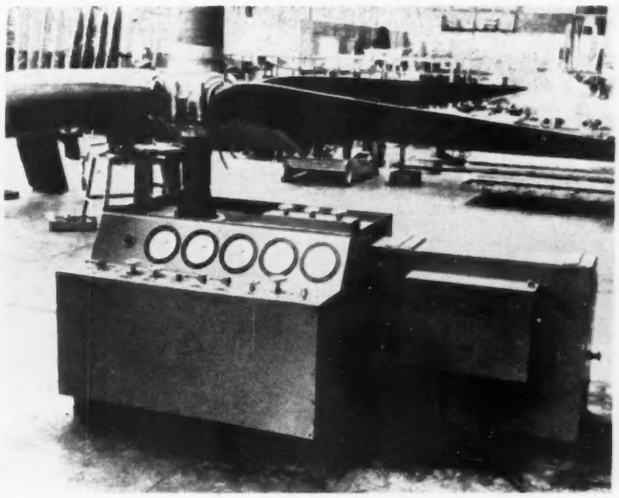
In the central station the fan/motor group is separated from the filter/heater/cooler group and pushes air through the plant, an arrangement which economises in refrigeration. There is a fully automatic balanced fresh and return air mixing unit with a circular damper which takes up the same position for the same fresh and return air conditions irrespective of whether the connections are being opened or closed. A high efficiency aerofoil runner is fitted to the fans which are directly driven by 1750 r.p.m. motors, both fan motor and runner being easily removed. A manually-operated smoke damper is built in and the filter cells are standardised at one size, while all moving parts are separated acoustically from static elements by means of flexible connections. The tube-in-tube anti-freeze copper gilled heater is fitted with an automatic self-acting control and the three sizes of cooler and heater coils are fully interchangeable and self-draining, and can be removed without disturbing pipework or insulation. Thermal and acoustic insulation is built in as in an automatic humidifier. The sizes and corresponding capacities are as follows:

Size	Capacity in cubic feet per minute
12	1200
24	2400
32	3250
48	4800
65	6500
96	9600

The central system obtains maximum assistance from outside conditions, by automatically balancing the intake of fresh air with return air, and provision is made for incorporating self-acting anti-freeze protection if required. The cabin terminal control unit is available in two sizes and both casing and glove are fully insulated, while the heat exchanger is completely enclosed and insulated when the control is in the "off" position. The heat exchange mechanism is claimed to be still reliable after 250,000 cycles without lubrication or servicing. The unit gives automatic temperature control through thermostats, of which there are two, room pattern and duct pattern, both being fully interchangeable. Consumption of compressed air is stated to be low, and the water temperature to the heating system "master" is compensated for fresh air temperature variations at all times. Since the capacity control of the refrigeration plant is fully automatic the consumption of power is a minimum.

[Reply Card No. E8702]





(Left) Back view of rig for hydraulic tests, showing the 75 h.p. A.E.I. Schrage variable-speed a.c. commutator motor. (Right) Propeller test rig. A table integral with the rig enables blade angles to be measured. The propeller is rotated by hand to bring each blade over the table

Test Rigs for Propeller Hydraulic Systems

To simulate any hydraulic operating conditions likely to occur on controllers or hydromatic propellers in flight, de Havilland Propellers, Ltd., has devised test rigs on which these assemblies are tested before delivery or after overhaul. The controller test rig is designed to be used for a variety of controllers and feathering pumps. The rig enables controller performance to be accurately evaluated in respect of delivery and leakage, control pressures, sensitivity of speed (revolutions per minute) control, and checks of special valve functions.

On this rig the controller under test is driven at the required speed by an A.E.I. Schrage motor (a variable-speed a.c. commutator motor) of 75 h.p. This motor has torque/revolutions per minute characteristics matching those of the hydraulic load ; its high momentum gives a steady speed under the load, and it has good response to speed adjustment, as is essential for this application.

The rig operates on a closed hydraulic circuit ; when the propeller controller is delivering from the coarse or fine pitch lines, the oil, after passing through the flow meter, is routed directly to the suction side of the controller gear pump, instead of into the main oil tank. This arrangement facilitates maintenance of a steady feed line pressure under a wide range of controller delivery conditions. High- and low-pressure oil pumps, driven by separate electric motors, supply to the controller feathering and feed lines respectively. The low-pressure pump, driven by an A.E.I. 1 h.p. squirrel-cage totally-enclosed fan-cooled motor, simulates the oil pump on the engines ; in normal closed-circuit running, the function of this pump is to replace the small amount of oil lost to drain by internal leakage in the unit under test. The high-pressure pump, driven by an A.E.I. 15 h.p. squirrel-cage totally-enclosed fan-cooled motor, generates the pressure necessary for static pressure and feathering tests. Internal leakage is checked for conformity with the specified limits by directing flow into the leakage gauge, which is fitted with a visual indicator.

A separate rig has been designed for testing the hydraulic functioning of a wide range of de Havilland "Hydromatic" propellers. This propeller test rig (illustrated) is a self-contained unit comprising basically a vertically mounted test sleeve which represents the engine shaft and contains oil supply lines for propeller operation. Integral with the rig is an extension of the main framework forming a table from which propeller blade angles may be measured. The propeller can be rotated by hand to bring each blade in turn over the table. The rig contains an oil pump, driven by an A.E.I. 15 h.p. squirrel-cage motor. The hydraulic circuit employs reducing valves and is arranged so that three separately controllable oil supplies are available from the single pump. Supply of oil to the propeller line or lines is controlled by cocks on the control panel and all propeller functions (such as feathering, braking, &c.) can be performed. Suitable tappings in the test sleeve permit checks of internal leakage to be made. Means are provided on the rig for controlling the temperature of the oil.

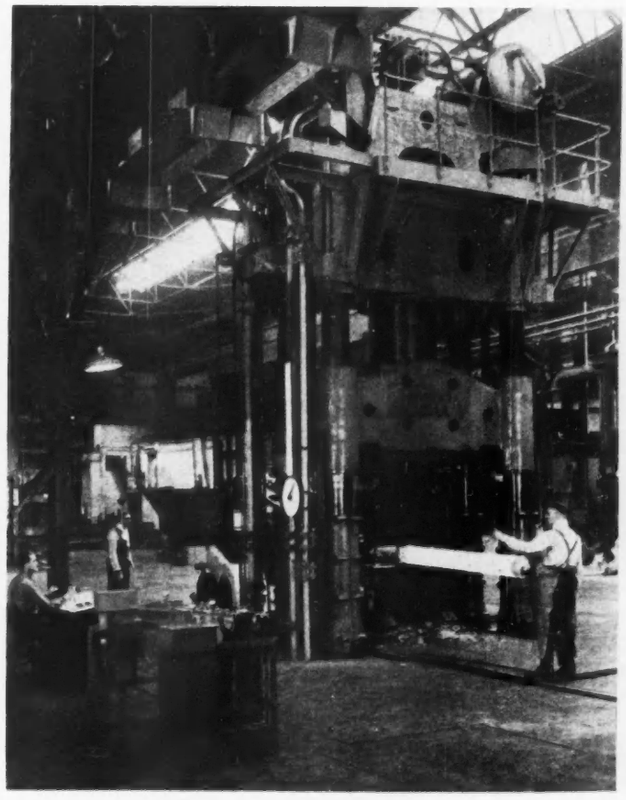
[Reply Card No. E8711]

Large Forge Development Scheme

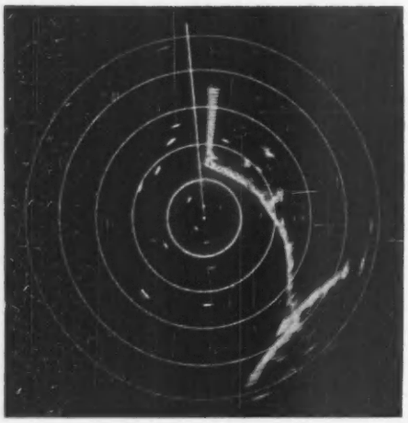
UNDER a development scheme which was started in 1953, in connection with the forging department of Thos. Firth and John Brown, Ltd., Sheffield, there was installed a new 1750-ton capacity press, together with the necessary furnaces and a 15-ton manipulator. Following this installation, a new shop was built for the accommodation of the 800-ton hydraulic press, shown in the accompanying illustration, with its furnaces and a 3-ton mobile manipulator. This press has an overall height of 26ft, its daylight being 9ft and its working stroke 4ft. Water at 4250 lb per square inch is used to operate the press and the full force of 800 tons is exerted at a speed of 6in to 8in per minute, provision being made for the operation with light planishing strokes at a rate of 120 per minute. Operation of the press is effected through light servo-controlled valves from a desk at the side of the machine.

Six furnaces at the side of the press are used to heat billets or ingots up to between 1150 deg. and 1250 deg. Cent. Two of these furnaces are heated by town gas and the remainder by producer gas, and they are all equipped for automatic precision temperature control. The handling capacity of the 3-ton mobile manipulator is supplemented by a 10-ton semi-Goliath crane and a 10-ton overhead electric crane serving the shop.

We are informed that the next stage in this development scheme will be the installation of a 4000-ton press in premises acquired from W. Griffiths and Sons, Ltd., in Brightside Lane, Sheffield. An old press in this shop will remain in service whilst the new one is being installed and the original hand-fired furnaces are being converted to modern producer gas firing. By the time the new press is ready, early in 1961, the furnace conversion work will be completed. The acquisition of these new premises will allow an extension of the Firth-Brown 1000-ton press bay and it is planned to install three further 800-ton capacity presses.



New 800-ton press in the Firth Brown forge



Typical response of "Racon" beacon, seen at a range of 3 miles

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[Reply Card No. E8693]

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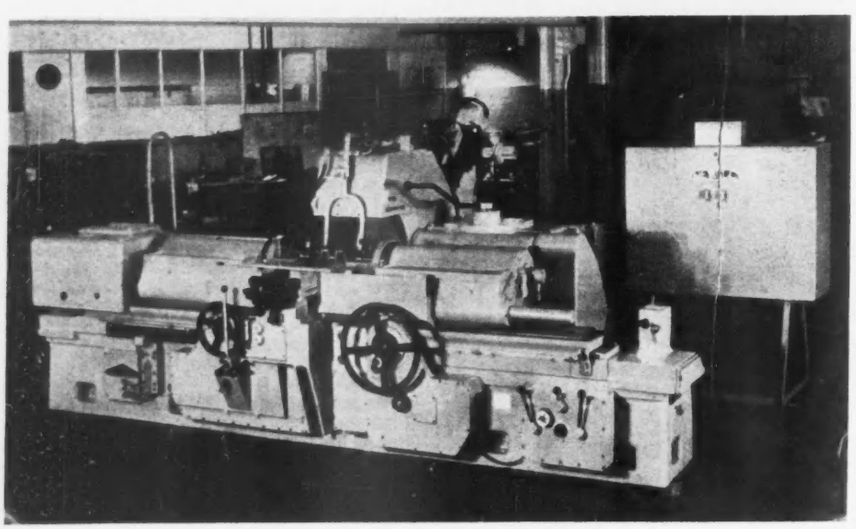
[Reply Card No. E8701]



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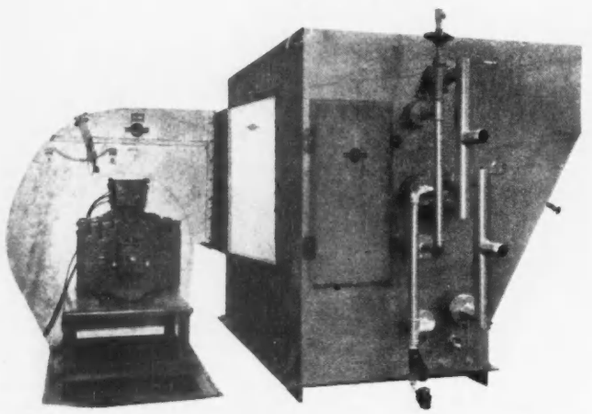

Central station air conditioning plant of 6500 cubic feet per minute capacity

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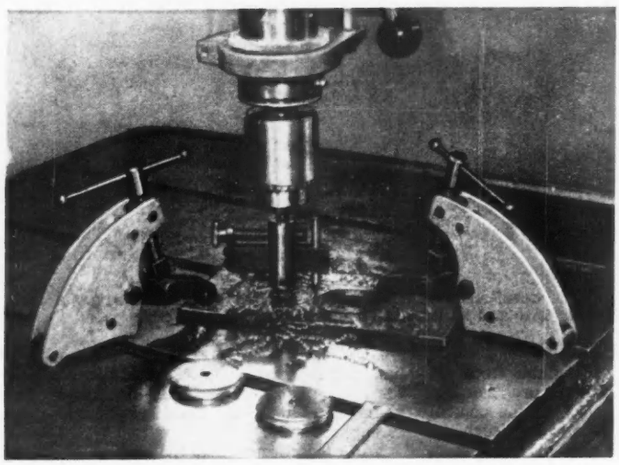
[Reply Card No. E8702]

Work Clamp

A USEFUL clamp for use on light machine tool tables, which is available from Odoni Equipment, Ltd., Salisbury House, London Wall, E.C.2, is illustrated below. This clamp can be adapted to fit into any standard tee-slot and can be rotated through a full circle on its support.

The clamping arm is pivoted in the body of the unit and its point of work-contact is about 2¾in from the front face of the body. The screwed spindle by which the arm is operated has sufficient length of adjustment to enable work up to 2¾in thick to be firmly held down on a table. An advantage of this design of clamp is that it has no loose parts which can be lost and that it can be quickly positioned and swivelled in a slot for use with various heights of work-piece.

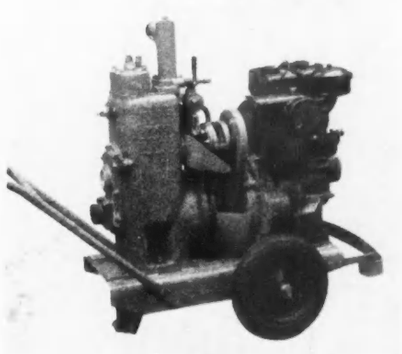
[Reply Card No. E8721]



Machine table with component held by "Odoni" clamps

Small Centrifugal Pump

A PORTABLE 2in centrifugal pump for contractors' and similar work has been added to the "Univac" range of pumps made by Henry Sykes, Ltd., Southwark Street, London, S.E.1. These pumps are available with a Lister 3 b.h.p. diesel engine drive, as illustrated, or with an electric motor drive. They can be mounted on a steel barrow, on a trailer chassis or bedplate mounted for fixed installation to suit particular requirements.



Portable 2in centrifugal pump with 3 b.h.p. diesel engine drive

Solids up to 1in diameter as well as dirty and gritty water or free flowing slurries, such as sewage sludge, can be passed by the pumps which are stated to give rapid self-priming and be capable of pumping on snore even at the maximum suction lift of 26ft–28ft. No priming water is required, air being removed before liquid enters the pump by a small vacuum pump capable of maintaining a vacuum of up to 23in–25in of mercury. With a vertical suction lift of 10ft the pump has an output of 6500 g.p.h. and with a lift of 26ft the output is 3300 g.p.h. When driven at 1500 r.p.m. the output ranges from 8000 g.p.h. with a total head of 20ft to 3000 g.p.h. with a head of 39ft.

The pump has a three-bladed impeller and cast iron wearing plates, all of which can be easily replaced when worn by liquids containing abrasives. The impeller shaft is coupled directly to the engine or motor shaft and is fitted at each end in the casing in a new design of gland developed by the makers. A small rotary exhauster is driven through a link vee-belt from the engine shaft and mounted in a readily accessible position.

[Reply Card No. E8722]

Processing Fine Materials

A ROTARY louvre equipment for drying and cooling very fine materials, made by Dunford and Elliott Process Engineering, Ltd., Linford Street, London, S.W.8, is designed to overcome the problem of limiting the speed of air flow in accordance with the fineness of a material to prevent fines being carried away. The principle upon which this process is based can be seen in the diagram.

Briefly, this rotary louvre drying and cooling equipment consists of a rotating horizontal drum with a series of internal radial plates on which the material being processed lies. A current of warm or cold air which is admitted through a series of tangential louvres passes through the bed of material as it is slowly turning over and travelling towards the discharge outlet.

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[Reply Card No. E8723]

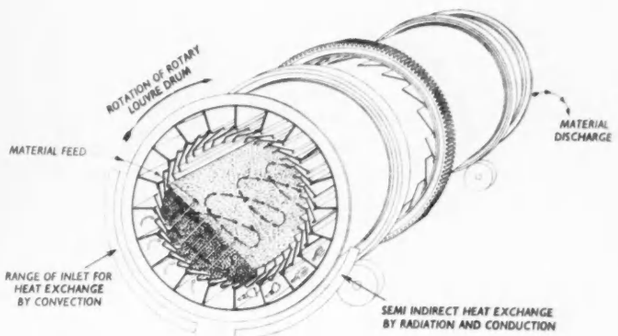
ROTATION OF ROTARY LOUVRE DRUM
MATERIAL FEED
MATERIAL DISCHARGE
RANGE OF INLET FOR HEAT EXCHANGE BY CONVECTION
SEMI INDIRECT HEAT EXCHANGE BY RADIATION AND CONDUCTION

Diagram of rotary louvre kiln for drying or cooling fine materials

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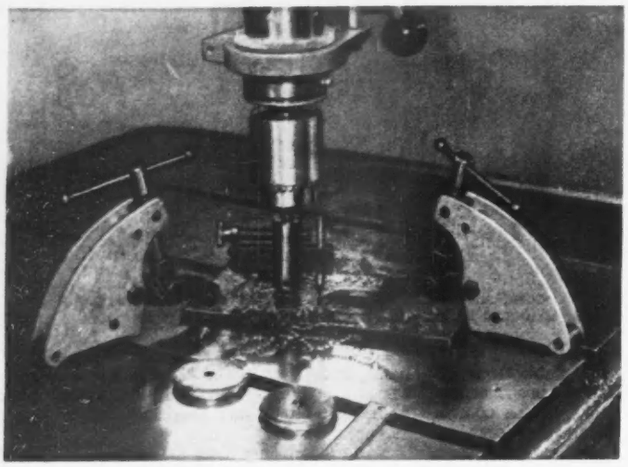
Work Clamp

A USEFUL clamp for use on light machine tool tables, which is available from Odoni Equipment, Ltd., Salisbury House, London Wall, E.C.2, is illustrated below. This clamp can be adapted to fit into any standard tee-slot and can be rotated through a full circle on its support.

The clamping arm is pivoted in the body of the unit and its point of work-contact is about 2¼in from the front face of the body. The screwed spindle by which the arm is operated has sufficient length of adjustment to enable work up to 2¼in thick to be firmly held down on a table. An advantage of this design of clamp is that it has no loose parts which can be lost and that it can be quickly positioned and swivelled in a slot for use with various heights of work-piece.

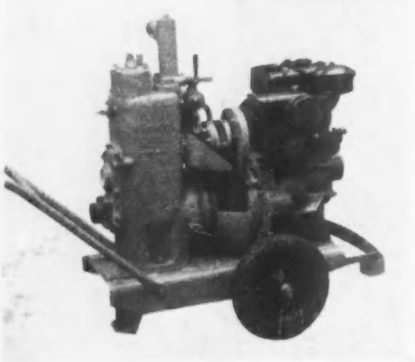
[Reply Card No. E8721]



Machine table with component held by "Odoni" clamps

Small Centrifugal Pump

A PORTABLE 2in centrifugal pump for contractors' and similar work has been added to the "Univac" range of pumps made by Henry Sykes, Ltd., Southwark Street, London, S.E.1. These pumps are available with a Lister 3 b.h.p. diesel engine drive, as illustrated, or with an electric motor drive. They can be mounted on a steel barrow, on a trailer chassis or bedplate mounted for fixed installation to suit particular requirements.



Portable 2in centrifugal pump with 3 b.h.p. diesel engine drive

Solids up to 1in diameter as well as dirty and gritty water or free flowing slurries, such as sewage sludge, can be passed by the pumps which are stated to give rapid self-priming and be capable of pumping on snore even at the maximum suction lift of 26ft–28ft. No priming water is required, air being removed before liquid enters the pump by a small vacuum pump capable of maintaining a vacuum of up to 23in–25in of mercury. With a vertical suction lift of 10ft the pump has an output of 6500 g.p.h. and with a lift of 26ft the output is 3300 g.p.h. When driven at 1500 r.p.m. the output ranges from 8000 g.p.h. with a total head of 20ft to 3000 g.p.h. with a head of 39ft.

The pump has a three-bladed impeller and cast iron wearing plates, all of which can be easily replaced when worn by liquids containing abrasives. The impeller shaft is coupled directly to the engine or motor shaft and is fitted at each end in the casing in a new design of gland developed by the makers. A small rotary exhauster is driven through a link vee-belt from the engine shaft and mounted in a readily accessible position.

[Reply Card No. E8722]

Processing Fine Materials

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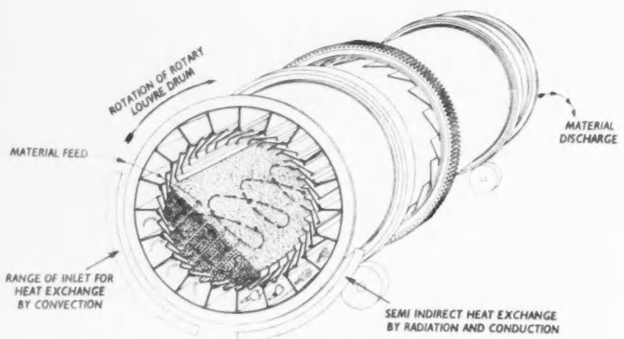
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Industrial and Labour Notes

United Kingdom Exports

The Board of Trade reports that in the three months, September to November, the value in total exports of United Kingdom products was 8 per cent higher than in the comparable period of 1958 ; between January and August, the increase compared with the corresponding period of 1958 was 3 per cent. The increase in the September-November period was widespread among products as well as countries of destination.

Exports of engineering products from September to November were 8 per cent higher than a year earlier, in spite of some decline in the exports of ships, aircraft and railway vehicles. The increase, it is stated, was the equivalent of £9,000,000 a month compared with an increase of £21,000,000 for all exports. Non-electrical machinery, with an increase of 16 per cent, contributed £7,400,000 and road vehicles and parts £5,900,000, with increases of 24 per cent in cars and 25 per cent in commercial vehicles and chassis. There were also increases of 7 per cent in the exports of electrical machinery, apparatus and appliances, and of 14 per cent in scientific instruments.

Exports to North America made the biggest contribution to the total increase in car exports between September and November, with Canada taking 51 per cent and the U.S.A. 15 per cent more than in the comparable period of last year. There were also large increases in motor-car exports to all the major West European countries, apart from France. The increase in machinery exports was similarly widespread. It included increases of 64 per cent to the U.S.A., 34 per cent to Canada, 28 per cent to India, 15 per cent to Australia and 89 per cent to Russia. During the period, iron and steel exports were 19 per cent higher than a year earlier and exports of non-ferrous metals were 10 per cent higher.

Export Service Bulletin

The Board of Trade states that from January 1, its " Special Register Information Service " is to be replaced by an " Export Service Bulletin." It will be published three times a week and will contain all the urgent information about overseas calls for tenders and export opportunities. In addition, a weekly supplement is to be published containing the latest economic and market commodity reports from the United Kingdom Commercial Diplomatic and Trade Commissioner Services overseas. The annual subscription for the bulletin (including the supplement) is to be £10 10s.

Unemployment

The Ministry of Labour has reported that, between November 16 and December 7, the number of unemployed in Great Britain fell by nearly 10,000. The total number registered as out of work on December 7 was 420,910, or 1·9 per cent of the estimated number of employees. On the comparable date last year, unemployment was 2·4 per cent of the total number of employees.

In the three-week period ended December 2, the employment exchanges filled 99,000 vacancies. The number of vacancies notified but remaining unfilled on that date was 251,000, which was 6000 more than in November.

Youth Employment Service

Last week, the Ministry of Labour published a report, which has been prepared by the National Youth Employment Council, on the work of the Youth Employment Service in the years 1956 to 1959. This report points out that, with the " bulge " of school leavers and the end of National Service, the number of men available for civilian employment during the next ten years will increase by about 1,000,000. Whether the country will be able to absorb such an increase, the report comments, will depend on the state of the economy. It goes on to say that if expansion should not be at a rate sufficient to absorb the additional number of workers available, the brunt would quite likely be borne by such groups as married women and older workers rather than by young people. The latter would be likely to suffer in comparison with adults only if a continued recession led to a cessation of recruitment in the interests of existing employees.

As the " bulge " develops, the report adds, the placing of school leavers must be expected to impose an increasing burden on the Youth Employment Service. A particularly difficult problem with which that service is likely to be faced in the coming years is the placing in employment of youngsters whose disposition or lack of ability make them a " less attractive proposition " to employers, who are liable to be more selective than they have been in the past. But the National Youth Employment Council also expresses concern over the prospects, during the next few years, of school leavers finding employment of the right kind and, in particular, employment that offers suitable training opportunities to those capable of benefiting from them. The council welcomes the setting up of the Industrial Training Council, though in the report it emphasises that local action in each individual area of the country is necessary to supplement the action being taken at national level in different industries.

Finally, the report makes the observation that the success of the Youth Employment Service depends on the quality of the individual youth employment officer. Youth employment officers, the report says, are doing admirable work but the training which new entrants receive is not always adequate, nor is it certain that the salaries and prospects offered by authorities operating the service are at present such as will continue to attract men and women of the right calibre.

Occupational Safety and Health

The Industrial Safety Division of the Royal Society for the Prevention of Accidents has announced that, early in the new year, it will begin to participate in an international scheme intended to promote wider understanding of industrial safety and allied subjects among safety officers, works managers, industrial physicians, trade unionists, and research workers. The essential aim of this scheme is to make information available rapidly and systematically, on literature and legislation dealing with all aspects of occupational safety and health. All kinds of industrial activity are to be covered, including engineering, mining and quarrying, agriculture, transport, dock work and public works contracting.

Distribution of the information is to be made through the International Labour Office by means of index cards. Literature to be dealt with includes reports, specialised publications of all descriptions, books and periodicals from countries throughout the world. Laws and regulations, codes, standard specifications and matters of a legislative nature will also be given systematic coverage. The cards, each with a classification code number, will consist of a complete index of subjects and cross references and each item of information will appear on only one card. Cards will be obtainable, in complete sets only, from the national organising centre which, in this country, is the Royal Society for the Prevention of Accidents. Other countries co-operating with the International Labour Office in this scheme are France, Germany, Italy, Austria, Belgium, Denmark, the Netherlands, Poland, Sweden and Switzerland.

The cost of this service to British subscribers will be £14 5s. a year. Inquiries concerning it should be sent to the Royal Society for the Prevention of Accidents, 52, Grosvenor Gardens, London, S.W.1.

Agricultural Machinery

According to statistics collected by the Agricultural Engineers Association, production of British agricultural machinery and tractors in the first ten months of this year was 11 per cent higher than in the comparable period of 1958. The Association says that, although exports of combine-harvesters this year were not much more than a third of the 1958 figure, the overall exports of the agricultural machinery industry are running at a rate 10 per cent above that of 1958.

Tractor exports this year have been 14 per cent above last year and now comprise more than three-quarters of the agricultural engineering industry's overseas sales. Apart from combine-harvesters, overseas sales of other farm machinery are 8 per cent higher than in 1958. As to the effect of the Common Market on British tractor exports, the Association says that, while German exports to the rest of the market area remain stable, Great Britain's have fallen by 5 per cent. On the other hand, in the Free Trade Association of the " Outer Seven," while German tractor sales have fallen by 7 per cent this year, Great Britain's have risen by almost 20 per cent. In Finland, British tractor sales this year have increased by £2,750,000.

Fire Protection Conference

The Fire Protection Association is sponsoring a National Fire Protection Conference which is to be held in London on February 25 and 26, 1960. This conference, the first of its kind, is to be attended by Home Office fire prevention experts, Ministry of Labour factory inspectors and by public and industrial fire brigade officers from all over the country. The importance of the conference to industry is emphasised by record figures for fire damage in 1959. Provisional estimates for this year up to mid-December put the losses at over £40,000,000, brought about mainly by an unusual number of large factory fires. The Fire Protection Association says that, in 1958 and 1959, there were at least five fires each causing material damage valued at over £1,000,000, and " experts fear that the day of the £10,000,000 industrial fire is approaching."

French Turbo-Drilling Experiences

Since January, 1956, when the first French-designed turbo-drill was tested at St.-Bauzille-de-Montmel near Montpellier, over 150 wells have been drilled in Europe and overseas. By October, 100,000m of boreholes had been achieved, including one to a depth of 1859m in the Paris region which required nine days to complete, compared with the usual eighteen days for rotary drilling. The greatest depth reached has been at Lacq (4600m), and the longest endurance to date by a single turbine has been 443 hours. Our article deals with turbo-drilling experience at Lacq, Hassi-Messaoud, and Coulommes.

UNTIL just after the first world war, the only methods in general use for drilling oil wells were those employing a vertical reciprocating motion. The tool was suspended from a string of rods or pipes, as in churn-drilling, or else a cable was employed for this purpose. By about 1930, these methods had been superseded in deep well drilling by the rotary technique, although cable drilling remains popular in the U.S.A. for shallow wells. At depths below 1600m, churn drilling was no longer economic, the main reason being the inefficiency of the transmission which allowed a specific power of only 25W to 40W per square centimetre to reach the bottom of the hole. Penetration rates with rotary bits are about twice as high as could be achieved with churn drilling. The weakness of the rotary system, however, lies in the fact that power has to be transmitted through rotating the torsionally weak drill string. Friction at the sides of the borehole grows in proportion to the depth and limits the amount of power reaching the tool. The answer to the problem was, therefore, to transmit power to the bit directly. For this purpose various means have been proposed including electric drives, but so far only the hydraulic turbine has proved successful.

Already in 1873, the American Cross had suggested the use of a turbine, but at that time his proposal did not prove feasible. Nearly half a century later, in 1922, the Russian M. Kapeliushnikov filed his patent for a turbine drill which was granted in September, 1924. In that year, the American Sharpenberg was granted a patent for a multi-stage turbine, but an actual design tested by the Standard Oil Company of California at Elk Hill in 1926 could not compete with the established methods at the comparatively shallow depths encountered, of 1100m–1200m.

In the Baku oilfield, on the other hand, the oil-bearing formations lie at 3000m–3500m depth, and this fact provided a considerable incentive for the Russian engineers to find ways of improving their drilling methods. Already in 1925 an industrial version of the Kapeliushnikov drill was produced. This employed a single-stage turbine together with a multi-stage planetary reduction gear. Similar designs arose in other countries, notably the French turbine of Lachamp and Perret of 1924, but in no case was the blading able to stand up to the high flow rates of 60m to 70m per second, and the reduction gears also could not be got to work successfully at the bottom of an oil well. The French experiments were abandoned in 1928, although the Russians continued this line of approach for another seven years. Eventually, in 1935, the idea of the multi-stage turbine won the day, since its lower speed of 600 to 1000 r.p.m. made it possible to drive the bit directly without reduction gearing. Many years were to pass, however, before the Russians, by using special steels and flexible bearings, finally succeeded in producing a drill which would stand up to the rigorous conditions encountered.

In France, oil is found at depths of 2500m to 3000m so that the motives for developing a turbo-drill were similar to those in Russia. The problem was taken up in 1954 by Etablissements Neyrpic, of Grenoble, on whose experience the following account is based.

The Neyrpic turbo-drill (Fig. 1) is a multi-stage unit comprising an outer casing the top end of which screws into the lowest pipe socket. Inside the casing are mounted the stationary parts of a multi-washer thrust bearing, and below, the turbine stator vanes. Between successive stator rings revolve the rotor stages. Underneath the motor section, which may comprise up to 100 or more stages, passages are provided through which the mud enters the hollow centre of the turbine shaft and flows to the drill bit which is attached below.

The turbo-drill has theoretical characteristic curves similar to those of ordinary hydraulic turbines. Thus, the graph of efficiency against speed for constant discharge is parabolic, with a maximum at approximately one-half the run-away speed. At this speed, the efficiency is about 65 per cent, while 68 per cent has been reached in recent laboratory tests. The torque curve falls away linearly from a maximum at stalling to zero at runaway speed, the torque at optimum efficiency being about half the maximum. The stalling torque is, however, not sufficient to endanger the drill string. Since the turbine speed can fluctuate rapidly by 100 per cent or so, it is of great importance that the pressure drop across the turbine should be constant in order to avoid dangerous surges within the hydraulic system ; the pressure drop is in fact very nearly constant over the full speed range. In actual operation the torque curve differs from the theoretical shape on account of bearing friction and reactions on the bit. Parallel with the design of blading, therefore, research is being carried out on thrust bearings, using a special test bed. Another installation makes it possible to test a complete drill under different operating conditions of discharge pressures, weight on the bit and torque (Fig. 2).

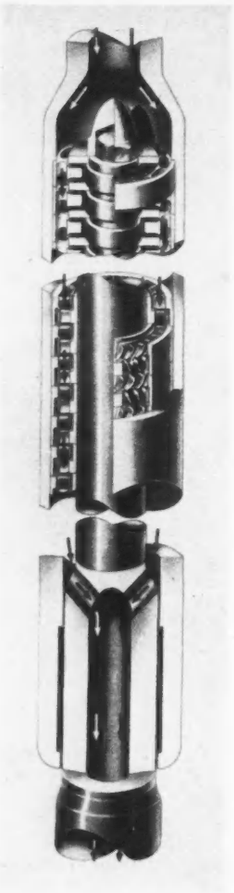

Fig. 1—Exploded section through drill turbine. The working fluid (drill mud) by-passes the thrust bearing and enters the blading which may have up to 100 or more stages. Afterwards the mud passes through the shaft centre to the drill bit

Various designs of turbo-drills have been produced to suit all bits currently used. A 10in diameter turbo-drill with eighty stages, each comprising a rotor and stator, has been developed for use with 12¼in to 17½in bits. This is stated to be specially suited to medium and hard formations. Soft formations require a much larger torque, and for such applications a turbo-drill of the same diameter but with 100 stages is employed. This machine can be coupled in pairs giving what is in effect a 200-stage drill. The same applies to a 7¼in diameter drill for 8½in to 12in bits. Smaller machines as well as 10in and 17¼in turbo-coring drills for wire line coring complete the range of deep drilling equipment.

The first application of the Neyrpic turbo-drill was in January, 1956, at Saint-Bauzille-de-Montmel in France. Since then, it has been used at Lacq, at Hassi-Messaoud in the Sahara, and at the Coulommes field near Paris.

The " Lacq 120 " well of the Société Nationale des Pétroles d'Aquitaine was drilled early in 1957 as a production well intended to tap the Lacq deep pool. This was the first time that only turbo-drills were used from a depth of 900m down to 2990m, the whole being drilled with 12¼in bits. At a neighbouring well, " Lacq 105 bis," rotary drilling was employed as a control, the geology being almost exactly the same, comprising from 900m to 2440m various formations of limestone, limestone marl, and dolomite.

The turbines used were models " TF.10-80," Mark I, II, III and IV, on a string of 5½in FH drill pipe. Two 10in drill collars were placed just above the turbo-drill together with variable lengths of 8in drill collars. One or two stabilisers were used at all times.

Maximum depth was reached by the turbo rig in 680 hours, while the rotary rig required 1950 hours. Weight on the turbine bit varied between 1 and 17 tonnes, and 1 to 8 tonnes on the rotary. The mud flow was 2600 litres to 3500 litres per minute with the turbine and 1800 litres to 2500 litres per minute with the rotary drill. In order to maintain such flow rates, pressures of 80 kg to 130 kg per square centimetre were required.

Performance at " Lacq 120 " and the average for the whole field are compared in Table I.

TABLE I—*Comparison Between Rotary and Turbo-Drilling at Lacq*

	Rotary (average at Lacq)	Turbo (Lacq 120)
Drilling time	1645 hours (to 2250m)	593 hours (to 1994·5m)
Mean penetration rate	1·36 m/hr	3·35 m/hr
Total time*	119 days	61 days
Hole drilled, monthly	565m	1050m
Time for round trips	322 hours	579 hours
Adding singles, fishing jobs	402 hours	Nil

* Including running in, pulling out, adding drill pipe, redrilling, circulation, fishing jobs, repairs and maintenance.

The table—based, it must be noted, on a single result—shows a saving of fifty-eight days at the well " Lacq 120 " as compared with the average for the whole field. About seventeen days—402 hours—were saved due to the absence of fishing jobs, but, on the other hand, more time was spent on round trips owing to shorter bit life (about 73 per cent of the average figure for rotary bits). The average endurance of a turbo-drill was 109 hours, while the maximum endurance attained was 190 hours.

In the twelve months to March, 1959, turbo-drilling was introduced at Hassi-Messaoud with a view to bringing this field into production as quickly as possible. Major difficulties

were encountered from the start. The pay formations are at a great depth and overlaid by alternating beds of abrasive and heaving rocks. The viscosity of the drilling mud could not be kept down as it deteriorated rapidly ; the presence of barites, salt, oil and gas, together with high down-hole temperatures and inadequate desanding, rendered the mud particularly erosive. Pump capacities were not high enough, and high pressures had to be maintained because of the depth and the weight of the mud, although the flow circulation rates of which the pumps were capable were low.

In the face of so many problems it was decided to deal with each difficulty in turn, first of all tackling a given interval with existing equipment to find out whether turbo-drilling was possible and economic, and to prepare optimum drilling programmes and decide on the improvements required. The work was undertaken jointly by Compagnie Française des Petroles (Algerie), Neyrpic, and Christensen Diamond Products.

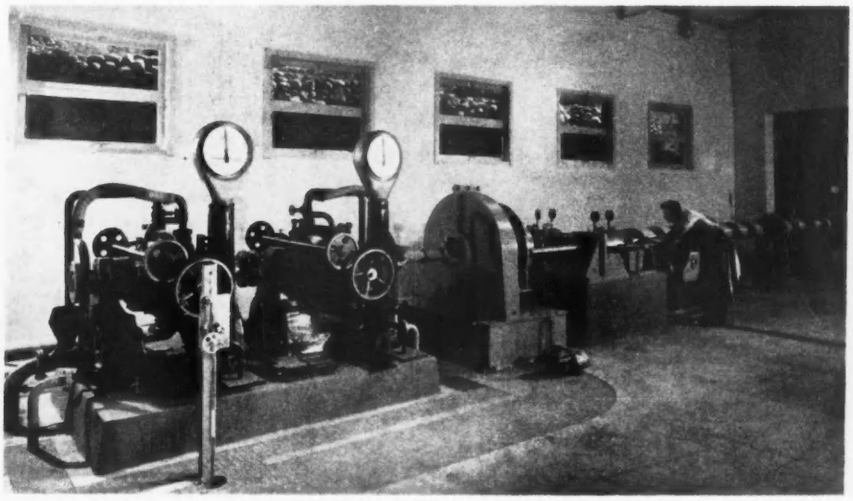

Fig. 2—Test rig for operating drill turbines under simulated field conditions

It was decided to begin with the 8½in interval, (about 2520m–3180m depth) and at the end of the period under review a total of nearly 2000m had been drilled in 500 hours, totalling about forty days' drilling on six wells. The most complete results were obtained on three wells belonging to C.D.P.A. Here "Super 7-11" rigs were employed, while the turbo-drills were mainly standard double 7¼in o.d., 220-stage models ; one of them is stated to have operated for more than 200 hours.

Broadly speaking, formations below the 9⅝in casings have comprised about 150m of anhydrite with salt and dolomite and streaks of clay, 100m of rock salt, another 50m of anhydrite, 200m of alternating beds of anhydrite and salt, and 200m of rock salt, followed by argillaceous sandstone.

Average penetration rates amounted to 1·5m per hour with rotary drilling and 3·25m per hour with turbo-drills, when using diamond bits of various designs. Eight such bits penetrated 1400m in 400 hours of turbo-drilling. Tricone bits proved useless in the hard formations but valuable for penetrating the salt ; in the review period, fifteen tricone bits were used to drill 600m in 100 hours.

The cost of drilling at these three wells is quoted to have been as high as with the best rotary drilled wells and in most formations much less than the average for a rotary well. The turbo-drill intervals are stated to have been perfectly vertical. Better penetration performances are expected in future drillings when it is planned to put into operation extra pump capacity, and turbo-drills fitted with deflectors and low leakage lower bearings. These and other improvements will, it is hoped, allow optimum working conditions to be approached.

A factor which militated against the turbo-drill was the intensive competition between drilling companies, which resulted in a preference for old and well-tried methods and a tendency to distrust the new technique. As elsewhere, it was noted at Hassi-Messaoud that the introduction of turbo-drilling stimulated the users of conventional methods to greatly improved performances. No final comparisons can be drawn owing to the fact that three turbo-drilled wells representing 2000m of hole and a few dozen bits must be evaluated against two years of rotary experience, forty completed wells, 30,000m of 8½in hole and hundreds of bits. Nevertheless, the impression is that turbo-drills are economically advantageous, at least on 8½in drilling. Promising tests were also carried out on the 12¼in interval, rat and mouse holes, and with spudding operations.

Experience with turbo-drilling has also been obtained in the Paris basin where it was introduced at the Coulommes field in November, 1958. Here some very favourable results have been achieved both in the 9⅝in casing interval (0m to 200m) and, provided adequate pump capacity was available, the 7in casing interval (200m to 1800m). Streaks of millstone grit in the former interval slow down rotary drills considerably, and at the same time frequently necessitate the use of 17½in bits in place of the 12¼in size normally employed. With turbo-drilling, the interval was penetrated in seven hours instead of over three days as with rotary drilling, and the constant diameter of the hole obtained sometimes made it possible to run the casing without a previous trial run. Turbo-drills are also being used to drill the rat and mouse holes on all wells.

Including all operations, from spudding to the Schlumberger run, the best time achieved so far has been nine days for drilling from 0m to 1859m, compared with eighteen days for rotary drilling.

The results quoted thus appear on the whole very satisfactory. To date the "Neyrfor" turbo-drill has been applied in drilling over 150 wells in ten countries in Europe, Africa and North and South America, and in October it was announced that a total of 100,000m of drill holes had been achieved. Application of the turbo-drilling technique is much facilitated by the fact that it can be employed using a standard rotary rig with very few modifications. Unless, however, mud pumps of ample power are available, i.e. about 1000 h.p. to 1500 h.p., depending on the sizes of turbine and bit, as well as on depth and other parameters, it becomes necessary to install additional pumps so as to maintain the optimum rates of flow. Since the power varies with the cube of the flow rate, a 2 per cent loss of flow causes something like a 6 per cent power reduction. The use of a pulsation damper is also very advantageous, as it prolongs the life of the equipment.

When drilling through sandstone or siliceous formations, cyclone desanders have to be used to remove suspended abrasive material from the drilling fluid. While existing bits appear suitable for turbo-drills in hard formations, there is much scope for developing special bits for use in soft strata.

It seems too early to pronounce on the comparative cost of rotary and turbo-drilling. Calculations indicate that turbo-drilling may result in savings of 10 to 15 per cent, and a 50 per cent increase in performance of the rig.

I.R.S.I.A. Annual Report

The Belgian Institut pour l'Encouragement de la Recherche Scientifique dans l'Industrie et l'Agriculture (I.R.S.I.A.) has issued its Report for the year 1958. The Institute received a subsidy of 192·5 million francs, 22,500,000 francs in excess of the amount originally budgeted. By means of subsidies amounting to over 233 million francs the Institut in its turn has maintained fifty-five research projects and assisted a number of others, involving a total personnel of 221 scientists and 399 technicians. The research projects include the manufacture of acetylene by pyrolysis, acetylene derivatives (including the effect of strong ionising radiations), a map of the soil and vegetation of Belgium, electronic calculating machines (transistor studies), studies in animal feeding, horticulture, agriculture, and veterinary science, metallic structures, a novel magnetic copying lathe, programme control by means of logical elements, electric and hydraulic control circuits, high duty lathes, and ceramic tooling.

In connection with high polymers, work was carried out on the resistance to tropical climates, irradiation, preparation of backing materials for photographic emulsions, and other topics. The Road Research Centre has continued its work on the properties of various road surfaces, soil load carrying capacity, fatigue resistance to bending, soil stabilisation with hydrocarbons (as used on the Antwerp–Liège motorway), drainage filters, and the use of neutron and gamma radiation, respectively, in the determination of the water content and density of soils.

Tracer techniques, using C^{14}, were employed by the Textile Research Centre to determine the amount of soap and detergents left in woollen fabrics after rinsing. The stability of quenched glass at temperatures up to 400 deg. Cent. is one of the tasks at the Centre of the Belgian Glass Industry. Further work is being carried out at Ougrée to establish a correlation between the behaviour of the experimental low shaft furnace and an industrial blast furnace. Researches in the field of solid state physics were concerned with photographic emulsions of higher sensitivity and new methods of obtaining a photographic image. A systematic study is being undertaken in the Gevaert laboratories of the behaviour of the latent image under varying conditions of humidity (10–95 per cent) and temperature (−30 deg. to +90 deg. Cent.).

The equation of state at pressures of over 1000 atmospheres is being studied for methane, and for mixtures, principally those of nitrogen and hydrogen, at up to 3000 atmospheres and 200 deg. Cent. This work will later be extended to cover ternary mixtures (N_2, H_2, and NH_3). The propagation of sound in gas under high pressure is being determined, in particular in the neighbourhood of the critical point. Other work concerns explosion inhibitors for acetylene.

A study is being made of the electrical resistivity of steel at high temperatures under conditions of yield. It is thought that resistivity measurements may be used to forecast the behaviour of the metal in industrial conditions for up to 100,000 hours.

Measurements will be carried out by the Shipbuilding Research Centre on seagoing vessels to determine the correlation between tank tests and actual performance. Hull stresses will be measured in a study of the ageing of vessels.

An experimental stretch of road between Zwartberg and Meeuven will be carried out in prestressed concrete.

Cold Strip Mill

THIS summer a cold rolling mill built by Maschinenfabrik Sack, Düsseldorf, was commissioned at the plant of Kaiser Aluminum and Chemical Corporation, Ravenswood (West Virginia). The mill consists principally of a two-high stand equipped with rolls of 560mm diameter and 1100mm long, for the rolling of aluminium and aluminium alloy strip, whether annealed or not. Special stress was laid on a high quality of the surface of the finished product. Depending on the nature of the material to be rolled, the reduction per pass ranges from 60 to 20 per cent. With a maximum initial thickness of 3mm, the largest strip width is 38in ; the minimum finished thickness is 0·15mm.

Single coils up to 3700 kg and double coils up to 4600 kg can be rolled with a maximum outer diameter of 1450mm. The rolling speed is steplessly variable from zero to 180m per minute. The rolls are screwed down by two d.c. motors electromagnetically coupled so as to allow combined or separate operation.

The whole installation comprises : a paper coiler in front of the rolling mill for coiling paper interleaving the incoming material ; an uncoiler with an expanding mandrel 508mm in diameter and 2000mm long, with four hydraulically operated segments; the roll stand itself ; a coiler identical in construction and size with the uncoiling machine, but having an arm above the mandrel for holding down the strip ; a belt wrapper with double paper uncoiler situated above it ; separate oil systems for lubricating the " Morgoil " roll bearings, the lubrication of all gears, the lubrication and cooling of the rolls and the rolled material, and the generation of pressure oil for the various hydraulic operations ; finally, there is an exhaust ventilation for removing fumes. Fig. 1 shows the complete plant assembled in the maker's works, while Fig. 2 gives an impression of the actual installation. The ample quantities of coolant used on the strip and rolls—some six to seven times the amount used for steel—are stated to play an important part in reaching the high surface finish and thickness tolerance required.

The design of the belt wrapper permits a quick replacement of the endless belt. The uncoiler and coiler are mounted on the same baseplates with their driving motors and reduction gearing. The mandrel overhangs the bearings and is suitable for single or double coils. When double coils are employed, one coil is unrolled first, after which a hydraulically operated pusher plate pushes the second coil into the uncoiling position facing the rolls. Special provision is made for exhausting the vapours and fumes from the rolling process, and for fire protection in view of the inflammability of the coolant emulsion employed.

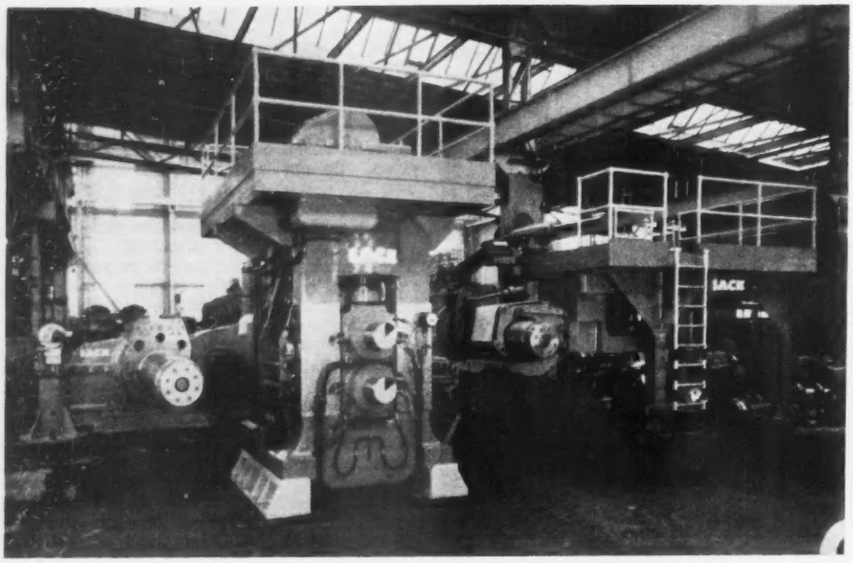

Fig. 1—Cold strip mill for aluminium and aluminium alloy (works assembled). From left to right : paper coiler, strip uncoiler, roll stand and coiling machine with movable belt wrapper. The endless belt can be quickly changed. The uncoiler and coiler are mounted on the same baseplates as their motors and reduction gearing

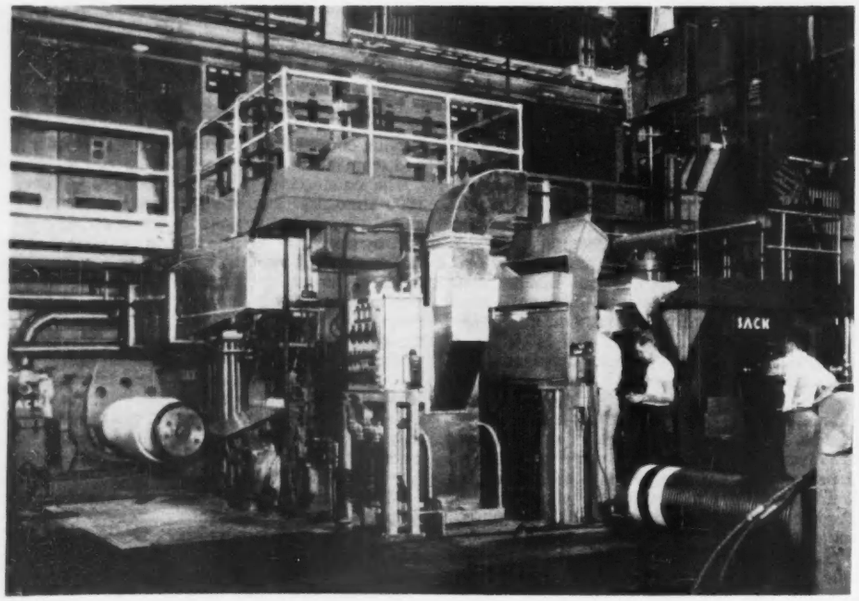

Fig. 2—Strip mill as installed, shown during trials

Combination Socket Outlet

In addition to 380V, three-phase connections for motors, industrial and agricultural enterprises generally require a certain number of single-phase outlets at 220V for handlamps, small power tools, and other temporary purposes. Frequently such socket outlets are inaccessible or completely absent.

The problem of providing a single-phase supply in addition to three-phase has been solved by the introduction of a combination socket by Siemens-Schuckertwerke A.G., Berlin and Erlangen. The system does away with the need for separate circuits for the two kinds of current. The combination sockets are housed in a cast iron casing, yet are small and light and suitable for mounting on an existing panel or on a wall. Each unit, as shown in our illustration, comprises a three-pole socket outlet for 380V and 15A, 25A or 60A, and a two-pole " Schuko " single-phase socket containing a fuse.

The two casings on the left show the combined-socket outlet for 380V, three-phase, and 220V, single-phase

The three-phase socket is protected by a hinged lid closing under spring pressure. When a plug has been inserted the lid engages with the plug and locks it in position, so that it cannot be pulled out by tugging at the cable. The single-phase socket is also protected by a lid which can be screwed down by a thumb screw. The supply cable can enter the socket casing either from the top or the bottom, for which purpose two tapped holes have been provided, the unused hole being closed by a threaded plug of insulating material.

200-Ton Floating Crane

ONE of the more important items of plant used during the construction of the 196MW Danube power station of Ybbs-Persenbeug was a 200-ton floating crane which was employed in connection with the erection of sheet piling around the working pits, the placing of stop logs, &c. Bought second-hand from M.A.N. in Germany, it was dismantled, taken to Austria and reassembled at the Linz shipyards. In view of the start of work on another major power scheme on the Danube at Aschach, it was decided by the Osterreichische Donaukraftwerke A.G. (DoKW) to have this crane completely overhauled and rebuilt. In particular, it is now provided with a new pontoon which takes the form of a single hull instead of two hulls connected by girders. The hull is 38m long, 16·2m broad and 3·3m high and, with 0·96m draught, has a displacement of 537 tons. It is subdivided into water-tight compartments for reasons of safety and carries the power plant, comprising two three-phase, 125kVA diesel generator sets. Arrangements have been made to enable this plant to supply electric power to the shore if required.

In addition, the hull contains the crew's quarters, including day room, kitchen, and hot and cold showers. The full crew comprises seven or eight persons.

Our illustration (Fig. 1) shows the crane during acceptance tests. It has a nominal maximum capacity of 2×100 tons at 11m radius, while previously maximum lift could only be obtained at up to 4·7m radius. The auxiliary hoist was also strengthened, from 15 to 20 tons. A protective system has been installed which prevents the lifting of excessive loads, and special indicators show the magnitude of the load at any time. The derrick has two tubular main struts with lattice cross bracing. Adjustable ties serve to vary the amount of reach. The hoisting speed for the main hoist is 1·3m per minute and for the small hoist 7·5m per minute. Motors comprise two 40kW motors for the main hoist, one of 30·5kW for the auxiliary hoist, and one of 22·8kW for the luffing machinery.

Water ballast of the order of 100 tons is admitted to the trim compartments so as to balance the effect of the load. Anchor winches and capstans are mounted both fore and aft. Our second illustration shows a view of the crane from astern in a position suitable for transport ; the lowered derrick is supported on barges.

Fig. 1—Floating crane showing acceptance tests. A load of 216 tonnes is being lifted by the two hooks

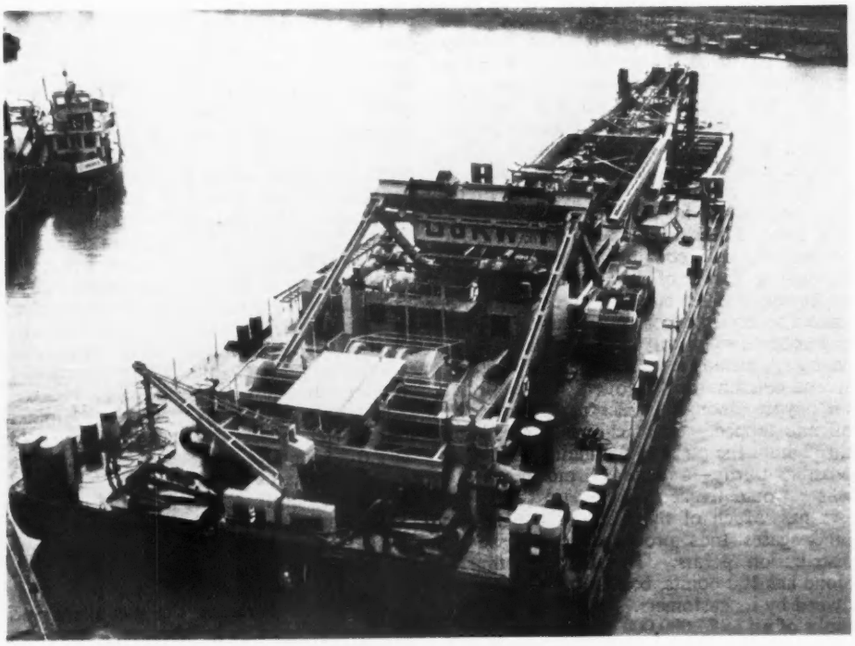

Fig. 2—Floating crane in transport position, seen from astern

Film Strips as Career Guides

The multiplicity of careers open to young people poses the problem of making a satisfactory choice, one which would give scope to the ambitions of those starting out upon their working life, and at the same time make the best possible use of their abilities. A joint committee of the Danish Trade Unions and Employers' Federations considered that as a first step it was essential to spread fuller information about the various careers, and accordingly sponsored—and voted money for—a series of film strips accompanied by a spoken commentary, illustrating various kinds of job, for showing in schools. The plan is that each major industry should collaborate with the committee and with the producer of the film strips to make a film strip and talk giving a candid sketch of the kind of work and working conditions to be found in the industry, the rates of pay, the advantages and the hardships. The Central Labour Exchange has agreed to arrange for distribution of the film strips provided they give an objective picture. The subsidy voted by the joint Trade Union/Employers committee is intended to help smaller industries with the expense of producing the large number of copies required for distribution to all the various schools.

The first of these film strips was produced with financial help from the Metal Workers' Apprenticeship Committee and shows the life of an apprentice in a big shipyard. The pictures show a youngster at the different stages in his training and the commentary is actually spoken by himself. An air of realism is given by including in the tape recording all the noise of a shipyard—riveting, hammering, welding and so on. In fact, the declared policy, well illustrated in this first film strip, is to make each item a talk with sound effects illustrated with pictures, rather than to lay stress on the pictures with only brief " caption-commentaries."

The first film having been approved by the various authorities concerned, it is now hoped to produce ten during 1959 and possibly as many as twenty-five in 1960.

Swiss Telephones Completely Automatic

With the recent completion of an automatic exchange at Scuol (Schuls) in the Engadine, Switzerland has become the first country in the world with a wholly automatic telephone system. In the course of the last twenty years, the Swiss Post Office has placed orders with private industry amounting to 2683 million Swiss francs. This total excludes telegraph and wireless installations and the cost of the buildings. Less than 5 per cent of the sum involved went to foreign firms. Revenue from telephones during the last twenty-one years has amounted to 1390 million Swiss francs, of which 520 million francs were used to balance the deficit of the other postal services, while 870 million francs went to the Federal exchequer. It is pointed out that these favourable results are a direct consequence of automatic operation.

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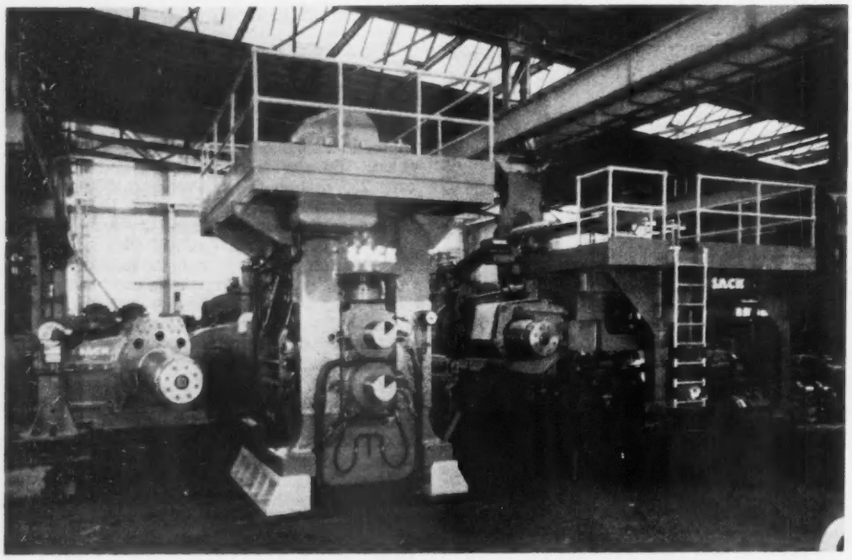

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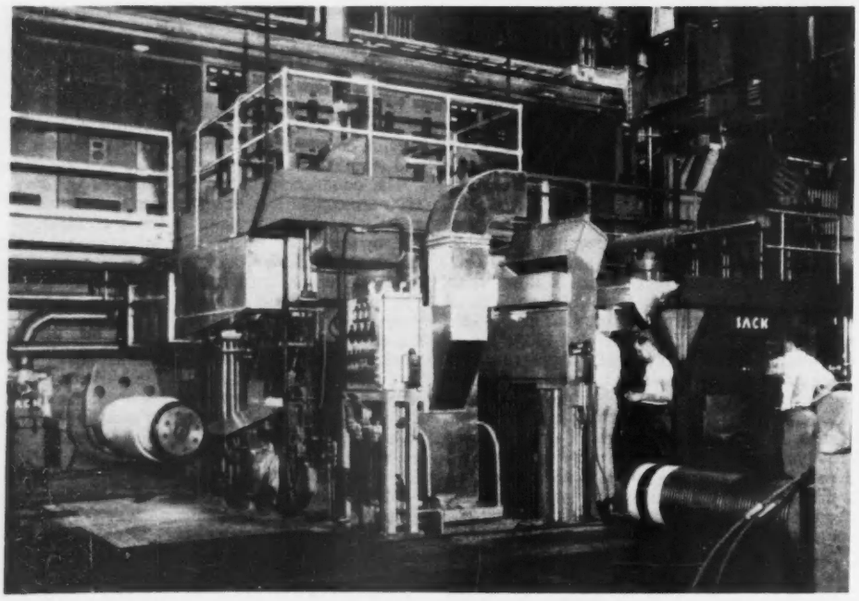

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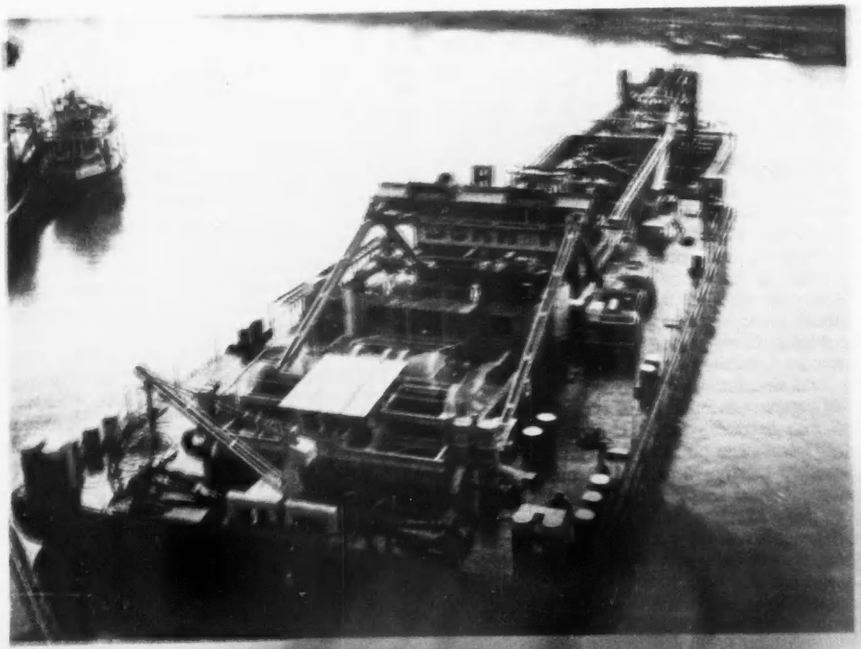

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The American Scene

BY OUR AMERICAN EDITOR

Cryogenic Progress

The research centre of the International Business Machines Corporation at Poughkeepsie, New York, recently obtained from Arthur D. Little, Incorporated, of Cambridge, Massachusetts, a remarkable kind of refrigerator. The machine was under development for over a year and is the first large-scale piece of equipment capable of re-cycling helium from a liquid to a gas and back again. It will enable engineers to drop the temperature in a sealed chamber to as low as −452 deg. Fah. and maintain it indefinitely, for long-range experiments on the new cryogenic computer circuits. The company hopes that one day it will be able to provide large electronic brains, containing—instead of valves, transistors and magnetic cores—ultra-thin films only millionths of a square inch in area and operating at speeds of millionths of a second. This striking piece of research is but one of many these days involving cryogenics—the science of very low temperatures. Industry long has known how to manufacture various kinds of cryogenic or liquid gases ; now it is rapidly expanding their technology. Cryogenics may be considered to date back to the mid-nineteenth century, when Lord Kelvin propounded the Joule-Thompson effect : a compressed gas, allowed to expand, will change its heat to the needed energy, thus cooling itself. Sooner or later, any cooled gas turns to liquid. Ordinary air does so, beginning at about −300 deg. Fah., and its constituents can be distilled out at −317 deg. Fah. By traditional definition, dating back to the first liquefaction of air, " cryogenic liquids " are those which change from the gaseous state at around −300 deg. Fah. or below. Freon, the synthetic gas universally used for everyday refrigeration, liquefies at −40 deg. Fah., and thus is not cryogenic. Neither are propane and butane, the liquefied petroleum gases. Methane, or natural gas, liquefies at the quite cold level of −258 deg. Fah. Its possible liquefaction for mass-shipment to European markets has aroused much recent interest and, while the gas itself is not a cryogenic, cryogenic techniques would be involved in its processing. Oxygen liquefies at exactly −297 deg. Fah., and is the cryogenic liquid with the highest boiling point ; nitrogen does so at −302 deg. Fah. Besides these, the cryogenic gases include argon (−302 deg. Fah.), fluorine (−306 deg. Fah.), neon (−410 deg. Fah.), deuterium (−417 deg. Fah.), hydrogen (−423 deg. Fah.), and helium (−452 deg. Fah.).

About the turn of the century, a series of discoveries occurred in the field of cryogenics. In particular, in 1892, Sir James Dewar developed the double-walled, vacuum-insulated vessel which made possible for the first time the storage of cryogenic liquids. Equipped with Dewars, Von Linde and Claude extracted oxygen from air and, in separate experiments, laid the groundwork for the modern, expansion-cycle liquefaction techniques. In 1908, Kamerlingh Onnes liquefied helium, thereby creating the coldest temperatures possible. Once engineers had liquefield all the gases, coming as close to absolute zero as is possible in this way, practical applications were not far behind. For cryogenics—quite apart from the cold temperatures involved—considerably reduces the volume of a gas. One compact cubic foot of liquid oxygen, for example, contains the equivalent of 800 cubic feet of the gas in its normal, usable state. First, however, industry had to learn how to conserve and handle the highly volatile cryogenic gases in this unnaturally cold and liquid state and in worthwhile quantities. The solution began to come in the late 'twenties, when the Germans saw the potential of rockets using liquid oxygen (LOX) to create combustion. During World War II, the U.S. Air Force created a demand for compact units of oxygen for breathing at high altitudes, and uses for the gas multiplied with the end of hostilities. The first low-pressure liquid helium cryostat was built by Professor Samuel C. Collins, of the Massachusetts Institute of Technology, in 1946. Four years later, a much improved version was perfected. Some 150 of these so-called Collins Helium Cryostats have been turned out by Arthur D. Little and sold to research centres here and abroad. Another milestone in the technology of cryogenics occurred in 1954. In that year Dudley Buck, a young post-graduate student at M.I.T., invented the " cryotron," a crude, but nearly microscopic, super-conductive switch made from the metals tantalum and niobium. When immersed in sub-zero cold, the cryotron performed switching operations like a vacuum valve or a transistor.

By and large, commercial applications of cryogenics have followed close on the heels of technology. Thus, the first and by far the largest is the manufacture and use of liquefied gases. Those found in the air inevitably have gained the widest markets. Argon and nitrogen are two of the three principal ones, but the third, oxygen, is much the most important. More than 70,000 million standard cubic feet probably will be produced in the United States this year, constituting a 15 per cent rise over 1958. The process involved is an intricate one. Air is forced into a tall tower by the suction of large compressor pumps. The compressors step up its pressure to 2200 lb per square inch, then force it into Freon heat exchangers for cooling down to −40 deg. Fah. Following this step, the cold air becomes its own coolant and power source through a series of heat exchangers and expansion booster engines which reduce it almost to liquefaction temperature. Then it is forced through an orifice at the " interchanger," turning it to liquid, and is sent to a second column, the " rectifier," where all but the oxygen among its constituents are boiled off and tapped. Great care must be taken throughout the plant to maintain the highest possible purity—a trace of moisture anywhere would freeze and clog up the whole system. Much of the LOX as well as the other gases thus produced is shipped to distribution points. The Linde Company alone has 100 points, besides hundreds more owned by its customers. Here it is stored in tanks of up to 75,000,000 cubic feet capacity, where it later is tapped for shipment in smaller containers to the many users—hospitals, aviation equipment suppliers and the welding industry. Bigger users, such as chemical plants, rocket producers and the military's test and launching sites, have LOX facilities of their own, from which they tap the blue liquid as required ; these are built by the gas producers. The biggest users of all the consumers of liquid oxygen are the steel-makers, who also have mammoth production plants adjacent to the mills. Nearly half of all oxygen produced in the United States to-day goes into steel. Thirty years ago, the mills used only 30 cubic feet per ton produced ; in 1945, the figure was just over 100. To-day, the industry consumes 450 cubic feet in the production of every ton —an average that still fails to indicate the true importance of oxygen in modern steel-making. The new Jones and Laughlin facility at Aliquippa, for example, uses 2000 cubic feet per ton. Air Products, Incorporated, and the Linde Company, are far out in front in the construction and operation of steel mill on-site plants. Air Products began building such facilities just after World War II, on sites adjacent to the customer's mills, and in many cases sold the plants outright to the users. Linde, however, chose to sell, to the same markets, gas produced at its large, centrally-situated plants, although it now builds on-site facilities as well. While usually more profitable, the sale of gas rather than plant also requires a much greater investment.

Besides the atmospheric elements, two other strategic gases are now coming into their own : hydrogen and helium. Until recently, liquid hydrogen was confined wholly to the laboratory. Too expensive to be commercially valuable, it was an exciting product without a market. Now, liquid hydrogen is finding its niche as a rocket fuel. The National Aeronautics and Space Administration is accelerating a three-stage rocket project called " Saturn," which is destined for outer space. Its third stage, a power-plant being designed by Pratt and Whitney, will be fuelled by hydrogen. The stepped-up U.S. programme to employ the chemical fuel with the greatest thrust involves many companies, but particularly the two which have been awarded volume contracts : again, Linde and Air Products. Linde has an experimental plant at Tonawanda, New York, from which it has been shipping liquid hydrogen in large containers ; a second, larger unit is under construction at Torrance, California. Air Products has built two prototype plants for the U.S. Air Force at Allentown, Pennsylvania, and earlier this year also put into production a very big plant at West Palm Beach, Florida. Liquid helium now is approaching similar status. Helium, of course, can be purchased only from the U.S. Bureau of Mines, which controls domestic production. The Bureau extracts helium from a few natural gas wells in the South-West, where it occurs in traces of 5 per cent or less, and ships it in pressurised-gas form to the Lakehurst Naval Air Station in New Jersey. Those who want liquid helium purchase the gas there and liquefy it themselves in laboratory cryostats. Now cryogenics is entering the picture at both the stages of production and transport.

Air Products has just put on stream, with the Fluor Corporation, a new plant for the Bureau of Mines at Keyes, Oklahoma, which is extracting up to 90 per cent of the available helium from a well containing some 2 per cent of the element. What is more, the company has nearly completed work on a U.S. Navy contract for the world's largest helium liquefier. The plant, which will be mounted on a semi-trailer, to make it movable from well to well, will convert 35,000 standard cubic feet per day of the gas to liquid on the spot. These first quantity runs of liquid helium will enable the Navy to carry as much gas in one semi-trailer cross-country as it used to haul in twenty.

Another Arthur D. Little cryostat of a quite different sort has come on the market as the product of United Aircraft's Hamilton-Standard division. Known as the "MinIR-cooler," it is the first miniature refrigerator to use re-cycled liquid helium. Moreover, it has been designed especially for use in an infra-red system and is less than 10 lb in total weight. The "business end" of the system is but 5in long, 1¼in in diameter, and weighs only 8 oz. The "MinIRcooler" requires but 100W of electrical input to operate, and generates only 2 B.Th.U. every hour. Yet it can cool an infra-red cell the size of a pea to —450 deg. Fah. in fifteen minutes or less. Systems for cooling IR cells to cryogenic temperatures have been available before. However, nothing combined the non-clogging features of the "MinIR-cooler" with its small size and range of cold temperatures. Thus, it has been considered a major advance, and Hamilton-Standard has been flooded with inquiries since the product was unveiled last spring.

On the non-military side, quick-freezing preservation of animal products is under study by several universities and industry. Syracuse University, for instance, has used cryogenics in artificial insemination experiments with cattle. The recently announced effective method for indefinitely storing human blood is regarded as a most important break-through, having implications for commercial refrigeration and freezing of other perishables as well. By a combination of intense agitation and immersion in liquid nitrogen, the scientists were able to quick-freeze blood and quick-thaw it without damage to corpuscles. They will attempt to achieve, within three years, the technology of freezing permanent blood banks on a "1,000,000 pint scale." Cryogenics also appears to portend new developments in electronics. In the realm of infra-red, commercial application of super-cold temperatures is near realisation. The technique may permit the sighting of an approaching missile at four times the distance or in one-third the time. Radar and microwave sensitivities also have been amplified greatly by the use of extreme cold. Finally, perhaps, the greatest research effort in the field to-day concerns super-conductivity—the phenomenon that reduces electrical resistance literally to zero in some ultra-cryogenically-cooled materials, thus making them far better conductors even than copper. The cryogenic computer on which I.B.M. is working is an astounding device. On thin glass surfaces, thousands of microscopic elements of lead, insulative film and tin are vacuum-deposited by evaporation. Such circuits, cooled cryogenically, appear to be better by far than any now available. One reason is their switching speed—at least fifty times more rapid than the fastest transistor. Another is the small size of the apparatus made possible by the fact that cryotrons produce incredibly little heat and so can be packed tightly together. What is more, the same units can be made to do memory work as well as switching, and they should never wear out. It is hoped that a basketball-sized computer of this sort can be fitted into a rocket or satellite, able to perform functions which to-day would require a transistorised version 50ft long. I.B.M. expects to have a fair-sized prototype ready in 1960, the military's model within five years, and a production model for commercial markets in ten years.

Reprocessing of Spent Nuclear Fuel Elements

THE U.S. Atomic Energy Commission recently assigned responsibility to provide for the processing of spent nuclear fuel elements from privately and publicly owned reactors. Under a policy previously announced, the A.E.C. has agreed to provide for such processing services until the time when they become available from private sources. The various Operations Offices of the Commission are now prepared to negotiate contracts with operators of nuclear reactors to provide for these chemical processing services. The assignments of specific fuels to four A.E.C. Operations Offices are in accordance with plans to process the spent fuels at the following sites: Hanford Works, operated by the General Electric Company at Richland, Washington; Oak Ridge National Laboratory, operated by the Union Carbide Nuclear Company, at Oak Ridge, Tennessee; Savannah River Plant, operated by E.I. DuPont de Nemours Company, at Aiken, South Carolina; and Idaho Chemical Processing Plant, operated by Phillips Petroleum Company, at the National Reactor Testing Station, Idaho Falls, Idaho. Assignments have been made for fuels from seventeen specific power and experimental reactors which are already in operation or under construction, as well as from those research and test reactors using uranium-aluminium alloy fuels. The reactors listed in the assignments include power plants financed in whole or in part by private industry, public or private utilities, or by the Federal Government. As other domestic and foreign projects come into operation they will be assigned in accordance with type and enrichment of fuel involved.

Reactor name and/or owner	Type of fuel element	Initial uranium enrichment
		Per cent
Hanford:		
Dresden Nuclear Power Station (Commonwealth Edison Company)	UO_2 in Zr tubes	1·5
Yankee Atomic Electric Company	UO_2 in stainless steel tubes	2·6
Shippingport Atomic Power Station (blanket only), (A.E.C. and Duquesne Light Company)	UO_2 in Zr tubes	Natural
Pathfinder Plant (Northern States Power Company)	UO_2 in Al-Ni plates	1·8
Piqua (A.E.C. and City of Piqua, Ohio)	U clad with Al-Ni	1·8
Oak Ridge National Laboratory:		
Enrico Fermi Atomic Power Plant (blanket only) (Power Reactor Development Company)	U-Mo alloy in stainless steel tubes	Depleted
Hallam Nuclear Power Facility (A.E.C. and Consumers Public Power District)	U-Mo alloy in stainless steel tubes	3·5
N.S. "Savannah" (A.E.C. and Maritime Administration)	UO_2 in stainless steel tubes	4·1
Consolidated Edison Thorium Reactor (Consolidated Edison Company of New York)	ThO_2-UO_2 in stainless steel tubes	90
Elk River (A.E.C. and Rural Co-operative Power Association)	ThO_2-UO_2 in stainless steel tubes	90
BORAX-IV—Boiling Reactor Experiment No. 4 (A.E.C.)	ThO_2-UO_2 in tubed Al plates	90
EBWR—Experimental Boiling Water Reactor (A.E.C.)	U-Zr alloy in Zr plates	1·5
SRE—Sodium Reactor Experiment (A.E.C. and Southern California Edison Company)	U rods in stainless steel tubes	3·5
Research Reactors (foreign)	U-Al alloy ...	20
Savannah River:		
Enrico Fermi Atomic Power Plant (core only)	U-Mo alloy clad with Zr	27
Idaho Chemical Processing Plant:		
Shippingport Atomic Power Station (core only)	U-Zr alloy clad with Zr	90
OMRE-Organic Moderated Reactor Experiment	U-stainless steel mixture clad with stainless steel	90
SM-1—Stationary Medium Power Plant (A.E.C. and U.S. Department of the Army)	U-stainless steel mixture clad with stainless steel	90
VBWR—Vallecitos Boiling Water Reactor (General Electric Company and Pacific Gas and Electric Company)	U-stainless steel mixture clad with stainless steel	90
SL-1—Stationary Low Power Plant No. 1 (A.E.C.)	U-Al-Ni in Al-Ni plates	90
Research and Test Reactors (domestic and foreign)	U-Al alloys ...	90

The technology and procedures of fuel processing to be used in handling returned fuels were discussed during the two-day Nuclear Fuel Processing Symposium held at Richland, Washington, in October. Representatives of the United Kingdom Atomic Energy Authority, and the Eurochemic Study Group (Organisation for European Economic Co-operation) also discussed aspects of their fuel processing programmes during the symposium.

The present announced assignments for spent fuel reprocessing are given in the table.

Cable Laying Ship Laboratory

TWENTY-EIGHT miles as the seagull flies, inland from ship lanes, a "cable ship" is now in the final stages of construction at Chester, New Jersey. The structure, firmly anchored to a hilltop, is a mock-up of the cable tanks and working decks of actual cable-laying vessels. The model will help engineers of the Bell Telephone Laboratories to carry out an extensive modernisation of cable ship equipment and techniques. The changes are needed to handle the improved underwater telephone cable systems which are now being planned. When the Bell Laboratories men "step ashore" from the cable ship, they are 900ft above sea level, on the slopes of windy Telephone Hill in the Laboratories' outdoor test centre. Above them, the structure stands 50ft high, extending nearly 200ft from stem to stern. Appropriately dubbed the "Fantastic," it is nevertheless immensely useful.

The mock-up will enable engineers to simulate deck layouts and cable handling operations of future and existing cable ships. During the cable-laying experiments, a winch pulls the cable out of the cable tank, down hill and around a sheave, simulating the cable being pulled into the sea by gravity. The present underwater cable system includes electronic repeaters, or amplifiers, spaced about 38 nautical miles apart. They are flexible and are handled like cable when laid in the sea. To transmit greater traffic in a proposed new cable system, however, it is now planned to use rigid, metal-encased repeaters, 3ft long and 1ft in diameter. Yet these rigid repeaters must be paid out with the cable, preferably through a cable engine and over whatever surfaces the cable must pass. Moreover, payout should be continuous, reliable and at reasonably high speed. To achieve this, a revolution in shipboard machinery and techniques is being brought about. The construction of a life-size mock-up was found to be more practicable and economical than chartering a cable ship for the long periods necessary. Many of the needed experiments could not be readily performed nor adequately observed aboard a real ship at sea. The skeleton vessel "Fantastic" enables the engineers to watch their experiments and to obtain motion-picture records for detailed study.

The nautically-minded engineers, enjoying their parts as seamen, have a set of international maritime signals they hoist at the yardarm—to tell any other ships in the New Jersey hills to stand clear of cable-laying operations!

Personal and Business

Appointments

MR. WALTER GRIFFITHS has been appointed sales manager of Flexipipe, Ltd.

MR. PAUL GOTLEY has been appointed general manager of Equipment and Services, Ltd.

MR. GEORGE B. COOKE and MR. J. S. MORTON have been appointed to the board of Efco, Ltd.

MR. LESLIE WILLIAMS has joined Frederick Parker, Ltd., as factory representative for Europe and the Near and Middle East.

THE PORT LINE, Ltd., announces that its superintendent engineer, R. W. Cromarty, has been appointed a director of the company.

THE WELLCOME FOUNDATION, Ltd., announces that it has appointed Mr. R. C. de B. Devereux as chief engineer to the Foundation.

QVF, Ltd., announces the appointment of Herr Wolfgang Mey as general manager of its German subsidiary company, QVF Glastechnik, Wiesbaden.

AIR CONTROL INSTALLATIONS, Ltd., has announced that Mr. J. H. Brindle has been appointed manager of the publicity department with effect from January 1.

MR. A. I. BAKER, M.I.Mech.E., has been elected president of the British Engineers' Association. The retiring president, Sir Edward Thompson, has been elected honorary treasurer.

PROFESSOR KENNETH GEORGE DENBIGH has been appointed to the chair of chemical engineering science tenable at the Imperial College of Science and Technology, from October 1, 1960.

MR. CHARLES WILLIAM REESTER, general manager of Mortimer Engineering Company, has been appointed to the board of directors of S. Guiterman and Co., Ltd., proprietors of Mortimer Engineering Company.

MR. G. P. DAVIDSON has been appointed managing director of Head Wrightson Processes, Ltd., with effect from February 1, 1960. Dr. R. C. Fisher has been retained to act as adviser on nuclear research reactors and other nuclear projects.

THE BRITISH IRON AND STEEL FEDERATION has announced that Mr. R. F. Summers will succeed Mr. Lewis Chapman as president on January 1, 1960. Mr. C. R. Wheeler has been appointed president-elect of the Federation for 1960.

MR. KENNETH BAIRD has been appointed personnel manager of F. Perkins, Ltd. Mr. K. J. Gerrard, who has been acting personnel manager since the retirement of Mr. R. Albon, will continue in this capacity until Mr. Baird takes over in the new year.

WOMBWELL FOUNDRY AND ENGINEERING COMPANY, Ltd., announces that Mr. Joseph Richards has been elected chairman in succession to Mr. Francis Hill-Cole, who has resigned his position owing to ill health. Mr. Hill-Cole continues as a member of the board.

Business Announcements

THE GENERAL ELECTRIC COMPANY, Ltd., states that its Leeds branch has moved from Wellington Street, to a new building in Gelderd Road, Leeds.

MERTON ENGINEERING COMPANY, Ltd., Feltham, Middlesex, states that the Merton Frontloader 59, is available with torque converter power-shift transmission.

THE DUNLOP RUBBER COMPANY, Ltd., has announced that Mr. John Bonar Maccoll, information officer and publicity manager since 1945, is retiring at the end of the year.

FISCHER BEARINGS COMPANY, Ltd., states that as a result of a recent agreement, Fafnir Bearing Company, Ltd., will acquire the business of Fischer Bearings Company, Ltd., as from January 1, 1960.

THE CEMENTATION COMPANY, Ltd., has announced the formation of a ground engineering division, comprising two main departments—cementation and geotechnical, at the company's headquarters at 20, Albert Embankment, London, S.E.11.

HORDERN-RICHMOND, Ltd., Bristol Road, Gloucester, states that as a result of an agreement with Templet Industries Incorporated of Brooklyn, U.S.A., it is now responsible for the European licence sales of the Templet industrial process.

IMPERIAL CHEMICAL INDUSTRIES, Ltd., Imperial Chemical House, Millbank, London, S.W.1, announces that it is to build a major extension to its trichloroethylene and perchloroethylene plants at Castner-Kellner Works, Runcorn, at a cost of £1,000,000. Reductions of £1 10s. per ton in the price of trichloroethylene, and £5 per ton in the price of perchloroethylene are being introduced on January 1, 1960.

HEAD WRIGHTSON AND CO., Ltd., states that the activities of its subsidiary, Head Wrightson Processes, Ltd., have been extended to cover all Head Wrightson's nuclear research and nuclear power interests. With headquarters at Yarm on Tees, Yorkshire, Head Wrightson Processes will be responsible for carrying out the work at Bradwell and Latina nuclear power stations, in addition to the research reactor projects in Denmark and Germany. With a London office at 20–24, Old Street, E.C.1, the company will continue to design and manufacture industrial cooling equipment, water treatment plant and specialised chemical plants.

Contracts

HALMATIC, Ltd., has received an order from John G. Alden and Co. Inc., of Boston, Massachusetts, for forty-five glass fibre hulls including: twenty 38ft yawls, four 47ft fast power boats, twenty 36ft sloops and one 67ft power boat.

W. H. ALLEN SONS AND CO., Ltd., has received an order to supply the propulsion machinery for a car ferry being built by Philip and Son, Ltd. The installation will consist of two engine-driven units and two motors each driving a paddle wheel through a reduction gear.

BIRWELCO, Ltd., has contracted to supply seven Petro-Chem Iso-Flow furnaces for the Esso Refinery on Milford Haven. The largest will have a duty of over 110 million B.Th.U. per hour and the remainder will have duties ranging from 60,000,000 to 110 million B.Th.U. per hour.

THE SHAW SAVILL LINE has placed an order with Vickers-Armstrongs, Ltd., for a passenger liner to run in conjunction with the "Southern Cross." About 1400 passengers will be carried in one class and the liner, of about 22,000 tons gross, will be propelled at 21 knots by machinery of 22,000 s.h.p.

THE GENERAL ELECTRIC COMPANY, Ltd., of England is to supply a power-operated manipulator, worth about £12,000, for the new nuclear research laboratories being built for the Central Electricity Generating Board at Berkeley, Gloucestershire. These laboratories will be equipped for the examination of irradiated fuel elements and of samples of structural components removed, on a programmed basis from the Board's nuclear reactors, for monitoring. The G.E.C. power manipulator will form part of the handling equipment for these materials, many of which will be intensely radioactive. The manipulator, like those ordered earlier this year by the United Kingdom Atomic Energy Authority, the Japan Atomic Energy Research Institute, and A.B. Atomenergi, Sweden, consists basically of a grasping device (hand or hook) mounted on a wrist, which is supported from a forearm, upper arm and shoulder. The shoulder is mounted at the lower end of a set of telescopic tubes suspended from an overhead crane-type carriage. Control is wholly electric, from a single console. The hand has a maximum grip force of 175 lb (80 kg), but is also capable of handling very delicate objects; the wrist has a torque of up to 40 lb-ft (5·5 kg-m). With all arm components vertical, a load of 750 lb (340 kg) can be lifted by the hook. The main contractor for the equipment of the Berkeley laboratories is H. M. Hobson, Ltd., of Wolverhampton.

Miscellanea

HIGH VACUUM VALVES.—A hand-operated straight-through high vacuum valve is now available in four sizes, 1in, 2in, 4in, and 6in, from Vacuum Research (Cambridge), Ltd., Bridge Street, Cambridge. This design of valve has a compact aluminium casting which can be used down to pressures of 10^{-6}mm Hg. Absolute. When the valve is open, the disc is withdrawn completely into the body to give an unobstructed passage through the valve. The valve is closed by rotating its lever through 180 deg. and at the end of this movement the valve plate is locked in the closed position. It can be used with atmospheric pressure on either side of the valve plate.

FLAMEPROOF TANK GAUGE.—A new model of the "Gilbarco" electronic tank gauge for use on deep storage tanks is announced as being available from Firth Cleveland Instruments, Ltd., Stornoway House, Cleveland Row, St. James's, London, S.W.1, a member of the Firth Cleveland Group. The new model, "CMB 107U," is housed in a ductile iron case and meets American Class I, Group D, Division I flameproof requirements. The gauge reads the true level of the liquid in feet, inches and sixteenths, regardless of specific gravity, and can be fitted with high and low level alarms. Accuracy is stated to be to $\frac{1}{16}$in in the field and $\frac{1}{64}$in in the laboratory.

PLASTICS VESSELS FOR CHEMICAL PLANT.—In the article "Plastics Vessels for Chemical Plant" which appeared on page 750 in our issue of December 4 last, the name of the plant makers should have been given as Cawley Plastics, Ltd., of Weybridge. The diameter of the 24ft high process tower for the chemical described was 3ft and not 6ft as stated.

PENETRANT FLAW DETECTION.—A new dye penetrant technique is marketed by Manchester Oil Refinery (Sales), Ltd., 76, Jermyn Street, London, S.W.1, under the name of the "Verimor" (solvent process). It has been developed to speed up the flaw detection of all components which are not attached to large structures. In this process the penetrant is removed from the surface, but not from the cracks, by dipping the specimen in a trichlorethylene vapour degreaser. The inspection technique is simply to apply the penetrant to the surface for ten minutes and then quickly dip the component for six to ten seconds in the vapour degreaser. The greatest sensitivity is achieved by the shortest wash consistent with no background. The component dries immediately after removal from the degreaser and when "Devmor" developer is sprayed on to the component any cracks are clearly shown.

STORM LANTERN.—An improved design of the 300 candle-power storm lantern made by the Tilley Lamp Company, Ltd., 70-72, Jermyn Street, London, S.W.1, is fitted with a rapid lighter, known as the "Tillite," making use of the paraffin and the pressure in the container of the lamp for pre-heating purposes. This lighter eliminates the necessity for a separate pre-heating device and it makes the new lamp a completely self-contained unit. It is stated that the "Tillite" requires only a minute and a half to light the lamp, compared with about three minutes of pre-heating by the previous torch and methylated spirits method. It produces a blue, powerful, continuous flame, which is free from carbon and pre-heating of the lamp, which can be effected in the open air under all but the stormiest conditions. The "Tillite" device not only simplifies lighting, but also acts as a safety valve in case of excessive pressure in the container, thus cutting out the dangers of overpumping.

THE RAILWAYS OF FRANCE.—Previous brochures similar to one just published by French Railways have been in French with an inserted English translation. The present publication is wholly in English and presents a copiously illustrated review of fixed equipment, motive power, rolling stock and operation. It includes several whole-page plates in colour. The text is written for the non-specialist, but even those who make a close study of railways are likely to find new information in this summary of widely-ranging development. The story is brought up to date with references to the Paris–Lille electrification and train radio-telephone services, and to the "panoramic" diesel railcars operated this summer on tourist routes. Naturally the advantages of 50 c/s electrification are stressed (relative prices of comparable a.c. and d.c. locomotives are quoted as £92,000 and £147,000 respectively) and reference is made to two forthcoming prototype locomotives for working in 25kV, 50 c/s a.c., 1500V d.c. and 3000V d.c., so covering both the French main-line electrification systems and that of neighbouring railways in Belgium and Italy.

FLEXIBLE JOINT FOR SALT GLAZED PIPES.—The National Salt Glazed Pipe Manufacturers' Association and the British Ceramic Research Association have completed development tests on a method of jointing salt glazed pipes by using a rolled ring formed from a rubber sleeve. It is claimed that a so-called "pressure joint" is obtained, with a high degree of flexibility, and that it has been used most successfully in field tests in various parts of the country. The principle is that a rubber sleeve approximately 3in long formed with a bead at one end, is placed on the spigot of the pipe with the bead at the spigot end. The spigot is then introduced into the socket of the next pipe and pushed home. It is a very simple operation to make a joint, we are informed, and although for 4in-6in diameter pipes there is a tool to lever the pipes together, it is just as easy to use the back of a spade if any mechanical aid is required at all. The rubber sleeves are to British Standard Specification No. 2494 prepared in 1955 for rubber joint rings for gas mains, water mains and sewers. It is stated that deflections under pressure of plus or minus 2½ deg. are easily accommodated. Another advantage claimed is that this particular method of jointing permits "draw" or linear displacement, and a draw of as much as ½in per joint is easily achieved in a pipeline under pressure, without leakage. It is expected that before long salt glazed pipes for fitting with flexible joints will be on the market under the registered name of "Flexadrain."

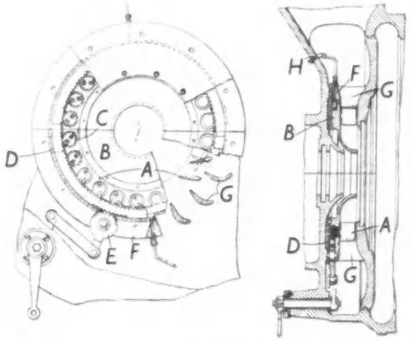
British Patent Specifications

When an abridgment is not illustrated the specification is without drawings, unless otherwise stated. The date first given is the date of application; the second date, at the end of the abridgment, is the date of publication of the complete specification. Copies of specifications may be obtained at the Patent Office Sales Branch, 15, Southampton Buildings, Chancery Lane, W.C.2, 3s. 6d. each.

COMPRESSORS

824,270. January 5, 1956.—CENTRIFUGAL COMPRESSORS, Dresser Operations Inc., Olean, State of New York, United States of America. (*Inventor: William Ernest Trumpler.*)

A principal object of this invention is to provide a compact and reliable mechanism for moving and positioning the inlet guide vanes ahead of an impeller of a centrifugal compressor. Each of the movable



No. 824,270

vanes *A* is mounted on a rotatable shaft which passes through disc *B*. Each vane shaft terminates in a pinion *C* set in a cut-out in the side of the disc opposite the movable vanes. A split internal ring gear *D* fits in a peripheral recess in the disc and its teeth mesh with the teeth of the pinions. This ring gear on its outer periphery meshes with the teeth of control pinion *E*. The control pinion is set in a recess in rim section *F* which is provided with a fixed guide vane *G* to direct the gas stream uniformly towards the movable vanes. Rim section *F* includes a groove to provide a lubricant channel around the split ring gear, and lubricant is supplied by way of fitting *H* which passes through the wall of the compressor casing and which is connected by tubing to the channel. Due to the close assembly clearances passages through which lubricant flows to the teeth of the ring gear and thence to pinions, the movable vane mechanism is a self-contained, grease-packed unit with a minimum of make-up lubricant required over a long period of time. The control pinion *E* has an arm which is linked to manual or automatic means (not shown) for moving the entire vane assembly in response to varying conditions of operation of the compressor from a wide open position of substantially radial alignment to one approximately at right angles, representing a fully closed position. —*November* 25, 1959.

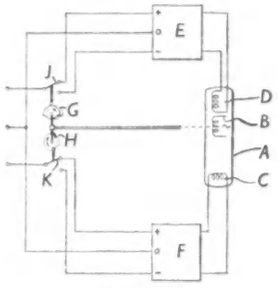
ELECTRICAL ENGINEERING

824,104. July 29, 1955.—ELECTRIC MOTOR CONTROL SYSTEMS, The English Electric Company, Ltd., Queens House, 28, Kingsway, London, W.C.2. (*Inventors: John McIntyre Ferguson and Allan Asbury.*)

This invention relates to an electric control system for a Ward-Leonard-Ilgner set, that is to say, a set in which a flywheel generator supplying an intermittent load, or a load subject to sudden large variations, is driven by a slipring induction motor the speed of which is controlled automatically by a liquid resistance slip regulator in its rotor circuit. The basic purpose of the slip regulator is so to control the resistance in the rotor circuit of the induction motor that the stator current does not greatly exceed full load current when the generator with its coupled flywheel applies torque greatly in excess of full load torque. The system commonly employed uses current transformers in the stator circuit of the induction motor to supply a three-phase torque motor which is mechanically coupled to the moving electrodes of the slip regulator, so that increase of stator current above full load value tends to draw out the electrodes and so increase the resistance. The principal drawback of such a system is that the torque motor has a very large inertia and the use of a simple balance weight system involves increasing the inertia of the moving members of the regulator. According to the present invention, the regulator is operated through a reversible clutch from continuously running driving means, and means are provided for controlling the clutch so that the regulator increases or decreases the resistance in accordance with the stator current of the induction motor. A scheme is illustrated in the specification in which an electromagnetic clutch has an input member driven continuously in one direction by a constant-speed three-phase motor, and an output member which may be caused to rotate in one direction or the other according to which of two clutch coils is energised. An electrical control signal dependent on the stator current of the motor driving the set is compared with a reference signal, and energisation of one or other of the clutch coils occurs according to whether the control signal is greater or less than the reference signal. The operating coils of the clutch are supplied through magnetic amplifiers. As an alternative to driving the clutch and slip regulator by a uni-directional motor, two oppositely-rotating motors may be used to drive the clutch input shafts. The application illustrated in the specification is that of a Ward-Leonard-Ilgner set supplying the driving motor of a rolling mill stand.—*November* 25, 1959.

824,211. March 25, 1957.—LOW FREQUENCY ELECTRICAL GENERATORS, The British Thomson-Houston Company, Ltd., Crown House, Aldwych, London, W.C.2. (*Inventor: Leslie Carter Ludbrook.*)

This invention has an important application in generating polyphase a.c. currents of very low frequency, i.e. of the order of 1 c/s. In a number of applications it is desirable to generate a very low frequency current, for example, in apparatus for stirring molten metal magnetically and in step-by-step drives for positional control apparatus. The drawing shows diagrammatically an embodi-



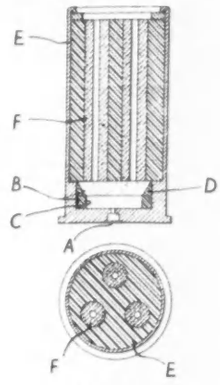
No. 824,211

ment of the invention which has a transmitter with a double-pole rotor and a two-phase stator. The transmitter is indicated by the reference *A* and is provided with a rotor *B* and stator windings *C* and *D* which are in quadrature. The winding *D* feeds a rectifying apparatus *E* and the winding *C* feeds rectifying apparatus *F*. Cams *G* and *H* control switches *J* and *K* respectively in the outputs from the rectifying units. It will be appreciated that the amplitude of the uni-directional output from the rectifiers will depend upon the angular positioning of the rotor *B* of the transmitter and the transmitter stator windings are so arranged that these amplitudes will vary with a quadrature displacement. The switches serve to reverse the polarity of the voltage passed to the terminals when the rotor has been rotated through more than 180 deg. and the switches will be so adjusted that this reversal takes place when there is substantially zero output from the corresponding rectifier.—*November* 25, 1959.

CARTRIDGES

821,731. March 28, 1957.—CARTRIDGE FOR USE AS A POWER UNIT, Olin Mathieson Chemical Corporation, East Alton, Illinois, United States of America.

This invention relates to an improved cartridge for use as a fluid power source in systems adapted to actuate moving parts in mechanical devices. In this cartridge there is a fuel charge having a resinous matrix with rods of smokeless powder propellant embedded in it. It is an object of this invention to provide a cartridge that can be easily modified to be used in a number of different fluid pressure systems and one that is easily ignited and consistently burns at a uniform predetermined rate. Referring to the drawing an aluminium cartridge case with a primer *A* has its head portion and adjoining side walls thicker than the remainder of the cartridge forming a well *B*. A spacer ring *C* lies against the head and supports an annular ring of black powder *D* enclosed in regenerated cellulose. Fuel *E* is a moulded grain that fits snugly in the cartridge and occupies substantially all of the space between the shoulder of the thickened head portion and a washer adjacent the open end of the cartridge case. The grain is composed of a resinous matrix and three hollow rods of smokeless powder base propellant *F* are set in the matrix. In this particular embodiment, each of the rods has the composition of about fifty parts by weight gelatinised nitro-cellulose having a nitrogen content



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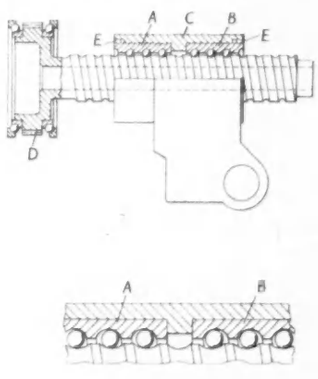
of about 13·25 per cent, about forty-five parts nitroglycerine, about three parts diethylphthalate, about one part ethyl centralite, about one part potassium sulphate, about 0·1 part candililla wax and about 0·1 part powdered carbon black. In another embodiment of the invention one of the rods has the same composition as that described above while the other two rods are of different composition. An apparatus suitable for moulding a propellant grain for the cartridge is described in the specification. —*October* 14, 1959.

MECHANISMS

822,582. January 17, 1958.—SCREW AND NUT MECHANISMS, Rotax, Ltd., Chandos Road, Willesden, London, N.W.10. (*Inventor: Terence William Millns.*)

The invention relates to a backlash free screw and nut mechanism of the kind in which the screw and nut are inter-engaged by a train of balls occupying the grooves. The nut consists of a pair of separate and similar cylindrical parts *A* and *B*. These parts



No. 822,582

are contained in the opposite ends of a sleeve *C* having at its centre an annular shoulder against the opposite sides of which the ends of the nuts abut. Rotation of the screw is effected through a gear *D* on one end of the screw. For interlocking the nuts and sleeve, each nut has formed on its outer end a castellated ring *E* and in each outer end of the sleeve is formed a complementary castellated socket. The pitch of the teeth or splines of the castellations at the inter-engageable ends of the sleeve and nut parts is arranged to enable a fine axial adjustment to be effected between the nuts. When such adjustment is required, either of the nut parts is first retracted for disengaging its castellated part from the sleeve, and after having received an appropriate angular movement it is slid into re-engagement with the sleeve. As shown in the lower drawing the width of the grooves is greater than the diameter of the balls. The effect of this is that when the screw is rotated in one direction the load is taken wholly by one of the nuts which is forced by the axial thrust into tight contact with one side of the shoulder. When the screw is rotated in the opposite direction the direction of the axial thrust is reversed and the load is then taken in like manner by the other nut.—*October* 28, 1959.

Launches and Trial Trips

STORRINGTON, raised quarter cargo ship ; built by the Burntisland Shipbuilding Company, Ltd., for Stephenson Clarke, Ltd.; length between perpendiculars 327ft, breadth moulded 48ft 8in, depth moulded 28ft 6in to raised quarter deck, deadweight 5000 tons on 20ft draught ; four holds, eight 3-ton derricks, hopper side tanks, electric winches, three 100kW diesel-driven generating sets ; Kincaid/Harland and Wolff - B and W, single-acting, two-cycle trunk piston oil engine, cylinders 500mm diameter by 900mm stroke, 1500 b.h.p. at 150 r.p.m. Launch, September 30.

MALOJA, oil tanker ; built by Smith's Dock Company, Ltd., for The Charter Shipping Company, Ltd.; length between perpendiculars 533ft, breadth moulded 71ft 3in, depth moulded 39ft 2in, deadweight 19,125 tons on 30ft 1in draught, service speed 14½ knots ; twenty-seven main cargo tanks, one main cargo pump room, four 300 tons per hour turbine-driven centrifugal cargo pumps ; two 450kW turbo-alternators, one 200kW diesel-driven alternator ; one set of Hawthorn Leslie single casing double reduction geared turbines, 7500 continuous shaft horsepower at 100 propeller revolutions per minute, steam supplied at 530 lb per square inch and 800 deg. Fah. by two Foster-Wheeler E.S.D. boilers. Trial, September.

Catalogues and Brochures

MUIRHEAD AND CO., Ltd., Beckenham, Kent.—Illustrated catalogue of precision electrical instruments.

SAFETY PRODUCTS, Ltd., Holmethorpe Avenue, Redhill, Surrey.—Illustrated leaflet describing a moulded fibre welding helmet.

JESSOP-SAVILLE, Ltd., Brightside Works, Sheffield.—Information sheets dealing with forging alloys for high temperature applications.

WOODSIDE DIE SINKING COMPANY, Ltd., Aire Vale Works, Newlay, Leeds, 13.—Illustrated folder dealing with some new tooling aids recently placed on the market.

A. A. JONES AND SHIPMAN, Ltd., Narborough Road South, P.O. Box 89, Leicester.—Brochure No. 237H, giving details of model 1400 surface grinding machine, 8in by 24in capacity.

LAURENCE SCOTT AND ELECTROMOTORS, Ltd., Manfield House, 376, Strand, London, W.C.2.—Publication No. 154, describing the "ASMAG" automatic control system for N-S variable speed a.c. motors.

THE HYMATIC ENGINEERING COMPANY, Ltd., Redditch, Worcestershire.—Leaflet giving details of the Hymatic-Hydrovane mobile compressor type 98P100. Figures of performance, dimensions and weights are given in both British and metric units.

TUBE INVESTMENTS, Ltd., The Adelphi, London, W.C.2.—Booklet entitled "This is TI To-day," listing the company's home and overseas subsidiary and associate companies and giving details of the products manufactured by companies in the United Kingdom.

Forthcoming Engagements

Secretaries of Institutions, Societies, &c., desirous of having notices of meetings inserted in this column, are requested to note that, in order to make sure of their insertion, the necessary information should reach this office not later than a fortnight before the meeting. In all cases the TIME *and* PLACE *at which the meeting is to be held should be clearly stated.*

ANTIQUARIAN HOROLOGICAL SOCIETY

Fri., Jan. 8.—Science Museum, Kensington, London, S.W.7, "Bells and Bellfounding," Douglas Hughes, 7 p.m.

BRITISH COMPUTER SOCIETY

Mon., Jan. 4.—MIDDLESBROUGH BRANCH : Constantine Technical College, Borough Road, Middlesbrough, "Experience with a Computer," N. C. Pollock, 7.30 p.m.
Tues., Jan. 5.—NEWCASTLE BRANCH : University Computing Laboratory, 4, Kensington Terrace, Newcastle, "Commercial Experience with a Computer," N. C. Pollock, 7 p.m.
Wed., Jan. 13.—BIRMINGHAM BRANCH : Large Theatre, Electrical Engineering Department, The University, Edgbaston, Birmingham, Symposium on "The Use of Computers for the Solution of Logical Problems—(*a*) 'Examination Timetables,' and (*b*) 'Railway Timetables,'" 6.30 p.m. ★ HULL BRANCH : Chamber of Commerce, Samman House, Bowlalley Lane, Hull, "Sorting and Summarising Methods for Computers," C. M. Berners-Lee, 7.30 p.m.
Thurs., Jan. 14.—BELFAST BRANCH : 29, University Square, Belfast, "The Use of a Computer in Business Planning," C. M. Berners-Lee, 7.15 p.m.

BRITISH INSTITUTION OF RADIO ENGINEERS

Wed., Jan. 6.—RADAR GROUP : London School of Hygiene and Tropical Medicine, Keppel Street, Gower Street, London, W.C.1, "Some New Possibilities in Civil Underwater Echo-ranging—Current Research at the University of Birmingham," D. G. Tucker, 6.30 p.m.
Mon., Jan. 11.—MERSEYSIDE SECTION : University Club, 2, Mount Pleasant, Liverpool, "High Frequency Propagation—Its Present and Future Use for Communication Purposes," A. F. Wilkins, 7 p.m.
Wed., Jan. 13.—LONDON SECTION : London School of Hygiene and Tropical Medicine, Keppel Street, Gower Street, London, W.C.1, "A Proposed Space-charge-limited Dielectric Triode," G. T. Wright, 6.30 p.m. ★ SOUTH WALES SECTION : Welsh College of Advanced Technology, Cardiff, "Television Broadcasting Methods" H. J. M. Hockley and N. Hughes, 6.30 p.m. ★ NORTH EASTERN SECTION : Institution of Mining and Mechanical Engineers, Neville Hall, Westgate Road, Newcastle upon Tyne, "Data Processing Machines," J. Allen and J. Keating, 6 p.m. ★ WEST MIDLANDS SECTION : Wolverhampton and Staffordshire College of Technology, Wulfruna Street, Wolverhampton, "Electronics in Medicine," P. Styles, 7.15 p.m.

BRITISH INTERPLANETARY SOCIETY

Sat., Jan. 9.—Lecture Theatre, Science Museum, London, S.W.7, Film Show on "Astronautics," 7 p.m.

ILLUMINATING ENGINEERING SOCIETY

Wed., Jan. 6.—SWANSEA GROUP : Demonstration Theatre, South Wales Electricity Board, The Kingsway, Swansea, Chairman's Address, J. R. Smith, 6.30 p.m.
Mon., Jan. 11.—SHEFFIELD CENTRE : Grand Hotel, Sheffield, Presidential Address, H. G. Campbell, 6.30 p.m.
Tues., Jan. 12.—GLASGOW CENTRE : Kenilworth Hotel, Queen Street, Glasgow, "Modern Lighting Techniques," M. J. Powley, 8 p.m.

INSTITUTE OF BRITISH FOUNDRYMEN

Wed., Jan. 13.—SOUTHAMPTON SECTION : Technical College, St. Mary's Street, Southampton, Film, "The Foundryman's Raw Materials," 7.30 p.m.
Thurs., Jan. 14.—BEDS AND HERTS SECTION : Town Hall, Luton, "Properties of Copper-Base Alloy Castings," F. Hudson, 7.30 p.m.

INSTITUTE OF MARINE ENGINEERS

Wed., Dec. 30.—WEST MIDLANDS SECTION : Birmingham and Midland Institute, Paradise Street, Birmingham, "Energy from the Atom," C. F. Powell, 7 p.m.

INSTITUTE OF METAL FINISHING

Wed., Jan. 13.—British Institute of Management, 80, Fetter Lane, London, E.C.4, "Stoving Paint Systems," A. W. Greig and F. G. Randall, 6.30 p.m.

INSTITUTE OF REFRIGERATION

Thurs., Jan. 7.—Institute of Marine Engineers, Memorial Building, 76, Mark Lane, London, E.C.3, "Some Lubricating Problems of Refrigerating Machines using Refrigerant 12," H. Heckmatt, 5.30 p.m.

INSTITUTE OF ROAD TRANSPORT ENGINEERS

Tues., Jan. 5.—WESTERN CENTRE : Royal Hotel, Bristol, "The Use of Plastics in Road Transport," J. Langford-Allen, 6.30 p.m.
Wed., Jan. 6.—EAST MIDLANDS CENTRE : Mechanics' Institute, Nottingham, "The Design and Construction of the Routemaster Bus," A. G. Higgins, 7.30 p.m.

INSTITUTE OF WELDING

Tues., Jan. 5.—CHRISTMAS LECTURE TO YOUNG PEOPLE : 54, Princes Gate, London, S.W.7, "The Magic Arc," Hugh O'Neill, 11 a.m.

INSTITUTION OF BRITISH AGRICULTURAL ENGINEERS

Mon., Jan. 4.—WEST MIDLANDS CENTRE : Room No. 118, Gosta Green, Technical College, Birmingham, "The Forage Harvester and Work Study in Relation to Silage Making and Feeding," F. S. Mitchell and N. W. Dilke, 7.30 p.m.

INSTITUTION OF CHEMICAL ENGINEERS

Tues., Jan. 5.—Geological Society, Burlington House, London, W.1, "Heat Transfer to Two-Phase Gas/Liquid Systems—Part I," J. A. R. Bennett, J. G. Collier, H. R. C. Pratt and J. D. Thornton ; and "Pressure Drop and Hold-Up in Two-Phase Flow," J. G. Collier, J. D. Thornton and J. A. R. Bennett, 5.30 p.m.

INSTITUTION OF CIVIL ENGINEERS

Wed., Jan. 6.—DUGALD CLERK LECTURE : Great George Street, Westminster, London, S.W.1, "Dredging Equipment," H. R. Cooper, 6.30 p.m.

INSTITUTION OF ELECTRICAL ENGINEERS

Mon., Jan. 4.—MERSEY AND NORTH WALES CENTRE : Donnan Laboratories, Vine Street, Liverpool, "Silicone Electrical Insulation," J. H. Davis, 6.30 p.m. ★ SOUTH MIDLAND CENTRE : James Watt Memorial Institute, Birmingham, Discussion on "Post-Graduate Academic Training Given within Industry," opened by R. F. Marshall, 6 p.m.
Tues., Jan. 5.—MEASUREMENT SUPPLY AND UTILIZATION SECTIONS : Savoy Place, London, W.C.2, "A New Method for Observing the Phenomena of Commutation," H. J. H. Sketch, P. A. Shaw and R. J. K. Splatt ; and "A Method of Measuring Self-Inductances Applicable to Large Electrical Machines," J. C. Prescott and A. K. El-Kharashi, 5.30 p.m. ★ NORTH-WESTERN CENTRE : Engineers' Club, 17, Albert Square, Manchester, Second Hunter Memorial Lecture, "The Protection of Electrical Systems," H. G. Bell, 6.15 p.m.
Wed., Jan. 6.—SOUTHERN CENTRE : C.E.G.B. Offices, Portsmouth, "Non-Destructive Testing," E. McCabe, 6.30 p.m. ★ TEES-SIDE SUB-CENTRE : Cleveland Scientific and Technical Institution, Middlesbrough, North-Eastern Centre Chairman's Address, H. Watson-Jones, 6.30 p.m.
Thurs., Jan. 7.—ORDINARY MEETING : Savoy Place, London, W.C.2, Second Hunter Memorial Lecture, "The Protection of Electrical Systems," H. G. Bell, 5.30 p.m. ★ WESTERN CENTRE : Technical College, Swindon, Joint meeting with the Western Branch of the Institution of Mechanical Engineers, "The 'Deltic' Locomotive," C. M. Cock, 6 p.m.
Fri., Jan. 8.—MEDICAL ELECTRONICS DISCUSSION GROUP : Savoy Place, London, W.C.2, Discussion on "Electrical and Electronic Techniques in Respiratory Research," opened by R. Woolmer, and D. W. Hill, 6 p.m.
Mon., Jan. 11.—ELECTRONICS AND COMMUNICATIONS SECTION : Savoy Place, London, W.C.2, "A Quadrature Network for Generating Vestigial-Sideband Signals," G. G. Gouriet and G. F. Newell ; "The Input Impedance of Rectifier Modulators," D. G. Tucker ; and "Rectifier Modulators with Frequency-Selective Terminations, with particular reference to the Effect of Even-Order Modulation Products," D. P. Howson and D. G. Tucker, 5.30 p.m. ★ NORTH-EASTERN CENTRE : Neville Hall, Westgate Road, Newcastle upon Tyne, "Research on the Performance of High-Voltage Insulators in Polluted Atmospheres," J. S. Forrest, P. J. Lambeth and D. F. Oakeshott, 6.15 p.m. ★ SOUTH MIDLAND SUPPLY AND UTILISATION GROUP : College of Technology, Gosta Green, Birmingham, "Electrical Supplies to Power Station Auxiliaries," D. A. Dewison, 6 p.m. ★ WESTERN CENTRE : The University, Bristol, "The Application of Low-Pressure Resins to Some High-Voltage Switchgear Designs," T. R. Manley, K. Rothwell and W. Gray, 6 p.m.

INSTITUTION OF ENGINEERING DESIGNERS

Wed., Jan. 6.—MIDLANDS BRANCH : Queens Hotel, Birmingham, "Measuring and Gauging Equipment," T. Ellerby, 7 p.m.

INSTITUTION OF HIGHWAY ENGINEERS

Wed., Jan. 6.—EAST ANGLIAN BRANCH : Assembly House, Theatre Street, Norwich, Film Show and Engineering Quiz, 6.45 p.m.

INSTITUTION OF MECHANICAL ENGINEERS

Mon., Jan. 4.—NORTH EASTERN BRANCH : Neville Hall, Newcastle upon Tyne, "Atomic Energy Factories : Design and Construction Problems," H. V. Disney, to be read by H. Norris, 6 p.m.
Wed., Jan. 6.—EAST MIDLANDS BRANCH : College of Further Education, Loughborough, Annual Meeting ; and "Design by Analogy," J. O'N. Fisher, 7 p.m.
Thurs., Jan. 7.—EASTERN BRANCH : Argyle Works, Stevenage, Chairman's Address, "Mechanical Seals," R. G. Allen, 7.30 p.m. ★ EAST MIDLANDS GRADUATES' SECTION : Gas Showrooms, Peterborough, "Some Aspects of Machine Tool Design for the Future," F. A. Lewis, 7.15 p.m.
Sat., Jan. 9.—EASTERN GRADUATES' SECTION: Visit to Reavell and Co., Ltd., Ipswich, 9 a.m. ★ LONDON GRADUATES' SECTION : Visit to Arthur Guinness Son and Co., Ltd., Park Royal, 10.30 a.m.
Tues., Jan. 12.—AUTOMOBILE DIVISION : 1, Birdcage Walk, London, S.W.1, Crompton-Lanchester Lecture, "Combustion Chamber Design and the Influence of Fuel Quality," D. Downs, 6 p.m.
Wed., Jan. 13.—LONDON ORDINARY MEETING : 1, Birdcage Walk, London, S.W.1, "The Strength of Rails with Particular Reference to Rail Joints," S. Wise, D. Lindsay and I. G. T. Duncan, 6 p.m.

INSTITUTION OF NAVAL ARCHITECTS

Thurs., Jan. 7.—10, Upper Belgrave Street, London, S.W.1, "The 'Brave' Class Gas-Turbine Fast Patrol Boats," J. T. Revans and A. A. C. Gentry, 4.45 p.m.

INSTITUTION OF PRODUCTION ENGINEERS

Mon., Jan. 11.—EAST AND WEST RIDINGS REGION : Hotel Metropole, King Street, Leeds, 1, "Production Engineering Problems in Connection with the Manufacture of Tubes," D. B. Such, 7 p.m.
Tues., Jan. 12.—EAST AND WEST RIDINGS REGION : Technical College, Doncaster, "Designing and Applying Carbide Tools," 7 p.m.

INSTITUTION OF STRUCTURAL ENGINEERS

Tues., Jan. 5.—NORTHERN COUNTIES BRANCH : Cleveland Scientific and Technical Institution, Middlesbrough, "Structures in Areas of Mining Subsidence," D. W. Cooper and J. D. Geddes, 6.30 p.m.
Wed., Jan. 6.—NORTHERN COUNTIES BRANCH : Neville Hall, Newcastle, "Structures in Areas of Mining Subsidence," D. W. Cooper and J. D. Geddes, 6.30 p.m.
Fri., Jan. 8.—WESTERN COUNTIES BRANCH : University Engineering Laboratories, Bristol, "Practical Applications of the Engineer's Training," C. E. Saunders, 6 p.m.
Wed., Jan. 13.—YORKSHIRE BRANCH : Royal Victoria Hotel, Sheffield, "The Clifton Bridge, Nottingham," R. M. Finch and A. Goldstein, 6.30 p.m.

JUNIOR INSTITUTION OF ENGINEERS

Fri., Jan. 1.—Pepys House, 14, Rochester Row, Westminster, London, S.W.1, Films, "Empire Links," and "Desert Bounty," 7 p.m.
Wed., Jan. 6.—MIDLAND SECTION : James Watt Memorial Institute, Great Charles Street, Birmingham, "Production Engineering in Textiles," G. A. Coglan, 7 p.m.
Fri., Jan. 8.—NORTH WESTERN SECTION : Engineers' Club, Albert Square, Manchester, "Human Relations in the Electricity Supply Industry," 7.30 p.m. ★ LONDON SECTION : Pepys House, 14, Rochester Row, London, S.W.1, "Coastal Shipping," H. Higgs, 7 p.m.

NEWCOMEN SOCIETY

Wed., Jan. 6.—Science Museum, London, S.W.7, "The Coalbrookdale Group Horsehay Works : Part 2," R. A. Mott, 5.30 p.m.

PLASTICS INSTITUTE

Fri., Jan. 1.—LECTURE FOR YOUNG PEOPLE : Institution of Electrical Engineers, Savoy Place, London, W.C.2, "Sticky Plastics," N. A. de Bruyne, 2.30 p.m.
Mon., Jan. 11.—MIDLANDS SECTION : Grand Hotel, Leicester, "Some Recent Developments in Plastics and Rubber Machinery," K. Wilson, 6.45 p.m.

REINFORCED CONCRETE ASSOCIATION

Wed., Jan. 6.—11, Upper Belgrave Street, London, S.W.1, "Vibration Control in Machine Foundations," J. H. A. Crockett, 6 p.m.

ROYAL INSTITUTION OF CHARTERED SURVEYORS

Mon., Jan. 4.—ORDINARY GENERAL MEETING : 12, Great George Street, Westminster, London, S.W.1, "The Effect of Industrial Development in Rural Areas," Colin Clark, 5.45 p.m.

ROYAL METEOROLOGICAL SOCIETY

Wed., Jan. 6.—49, Cromwell Road, London, S.W.7, "Mountain Waves," C. E. Wallington, 5.30 p.m.

SCIENCE MUSEUM—CHRISTMAS LECTURES FOR BOYS AND GIRLS

Mon. and Tues., Dec. 28 *and* 29.—Science Museum, South Kensington, London, S.W.7, "From Tinfoil to Tape : The History of the Gramophone," John Cain, 2.30 p.m.
Wed. and Thurs., Dec. 30 *and* 31.—Science Museum, South Kensington, London, S.W.7, "The Story of Flight," Victor Wall, 2.30 p.m.
Fri., Jan. 1.—Science Museum, South Kensington, London, S.W.7, "Science and Magic," John Cain, 2.30 p.m.

SOCIETY OF CHEMICAL INDUSTRY

Wed., Jan. 13.—CORROSION GROUP : 14, Belgrave Square, London, S.W.1, "Corrosion Problems of High Temperature Pressurised Water Reactors," J. N. Wanklyn, 6 p.m.

WOMEN'S ENGINEERING SOCIETY

Wed., Jan. 13.—LONDON BRANCH : Hope House, 45, Great Peter Street, Westminster, London, S.W.1, "Health Physics and Nuclear Power," B. C. Godbold, 7 p.m.

END OF VOLUME 208

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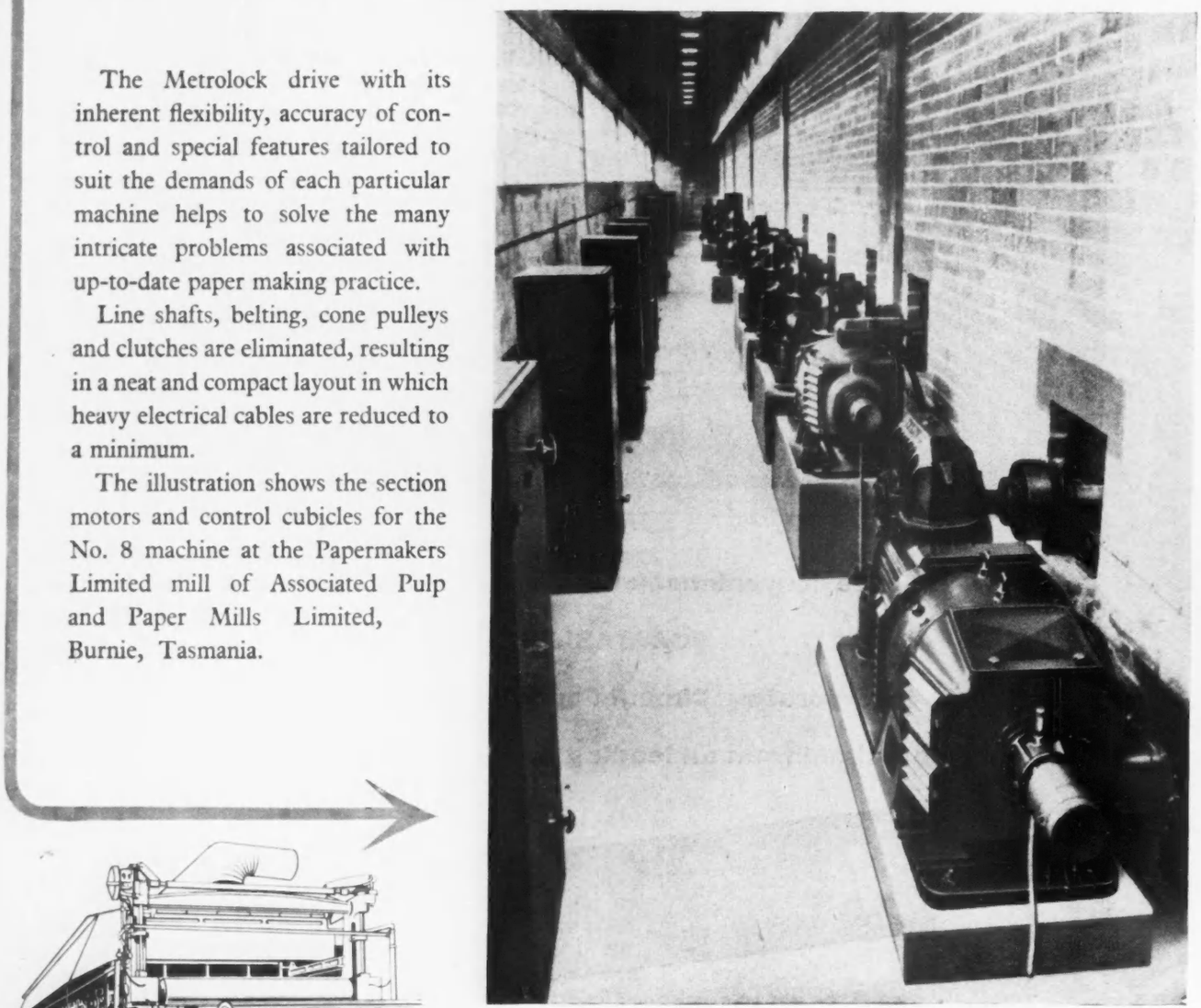
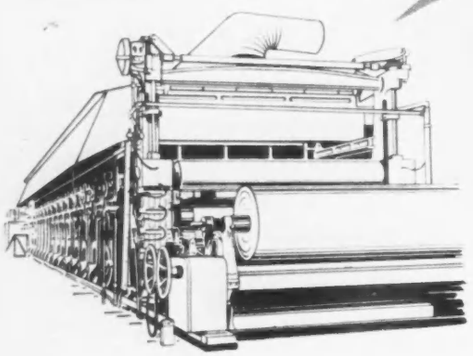
The illustration shows the section motors and control cubicles for the No. 8 machine at the Papermakers Limited mill of Associated Pulp and Paper Mills Limited, Burnie, Tasmania.



The drive annexe with section motors and control cubicles.



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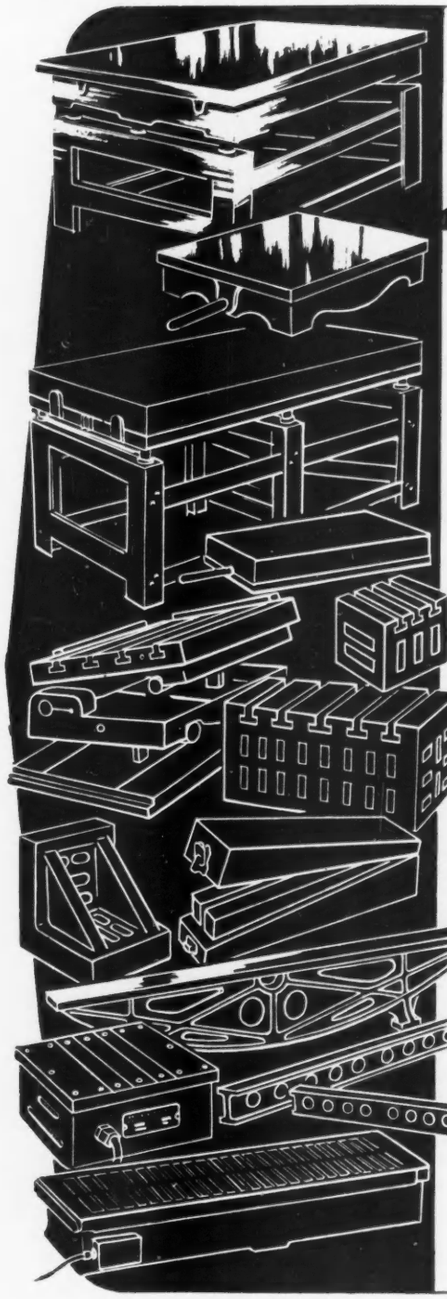

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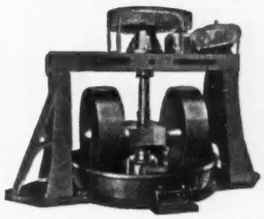

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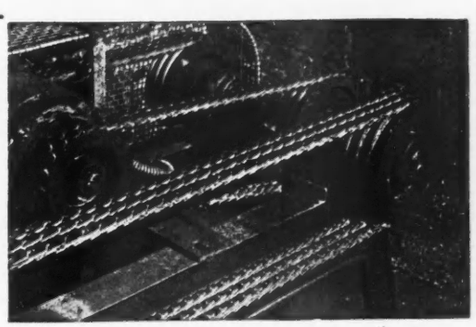

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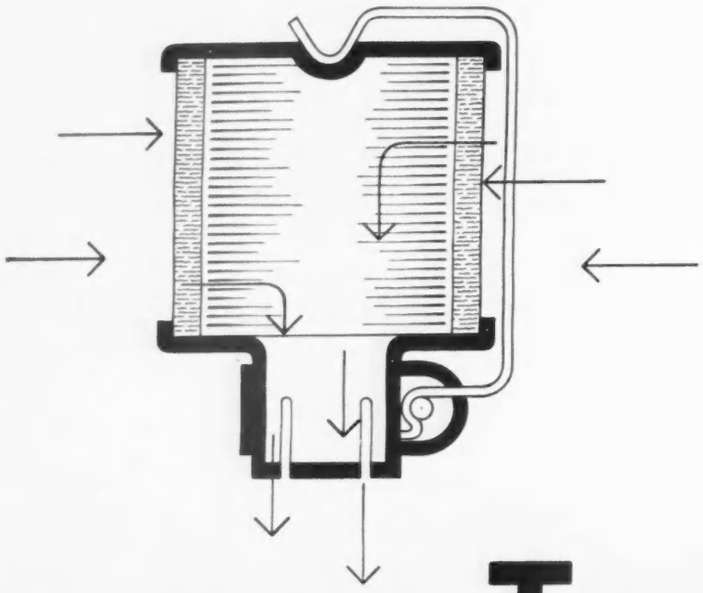

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Uses for Tecalemit Ribbon Filter Elements include: carburettor inlet filters for small engines; air intake filters for compressors and exhausters; water separators for fuel and air lines; filters and strainers for petrol, diesel, fuel and hydraulic oils, and oil burners, etc; engine crankcase breathers, and breathers for hydraulic tanks and systems.

Tecalemit ribbon elements filter to maximum purity

Tecalemit Air Breather Filter (incorporating Tecalemit Ribbon Filter Elements)

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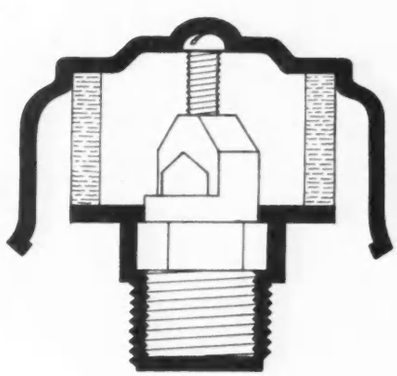

All are fitted with Tecalemit Ribbon Filter Elements, and are suitable for engine crankcases; air and vacuum brakes; hydraulic oil tanks and rams; gearboxes, pneumatic cylinders and servo mechanisms, etc.

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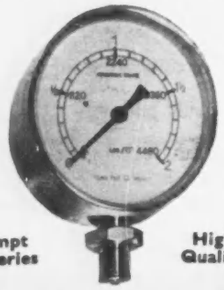

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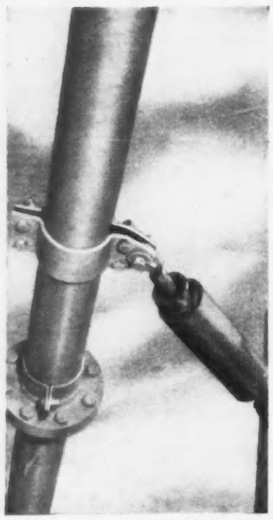

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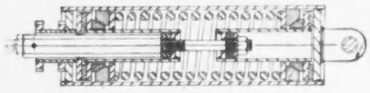
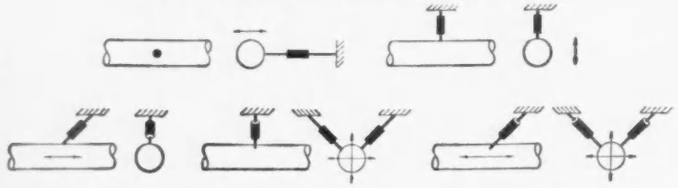


Vokes Genspring Non-Resonant Sway Braces

Sketches of suggested methods of application



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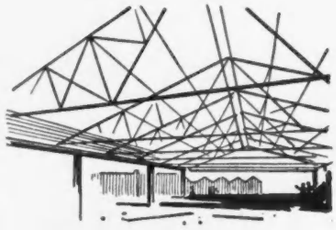

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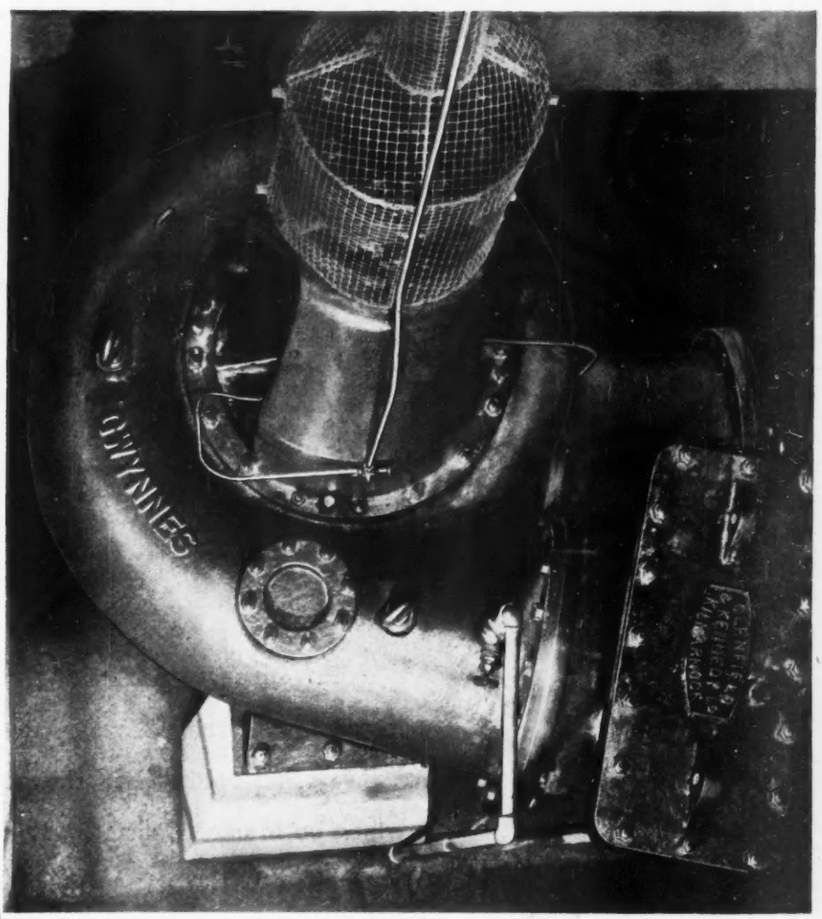

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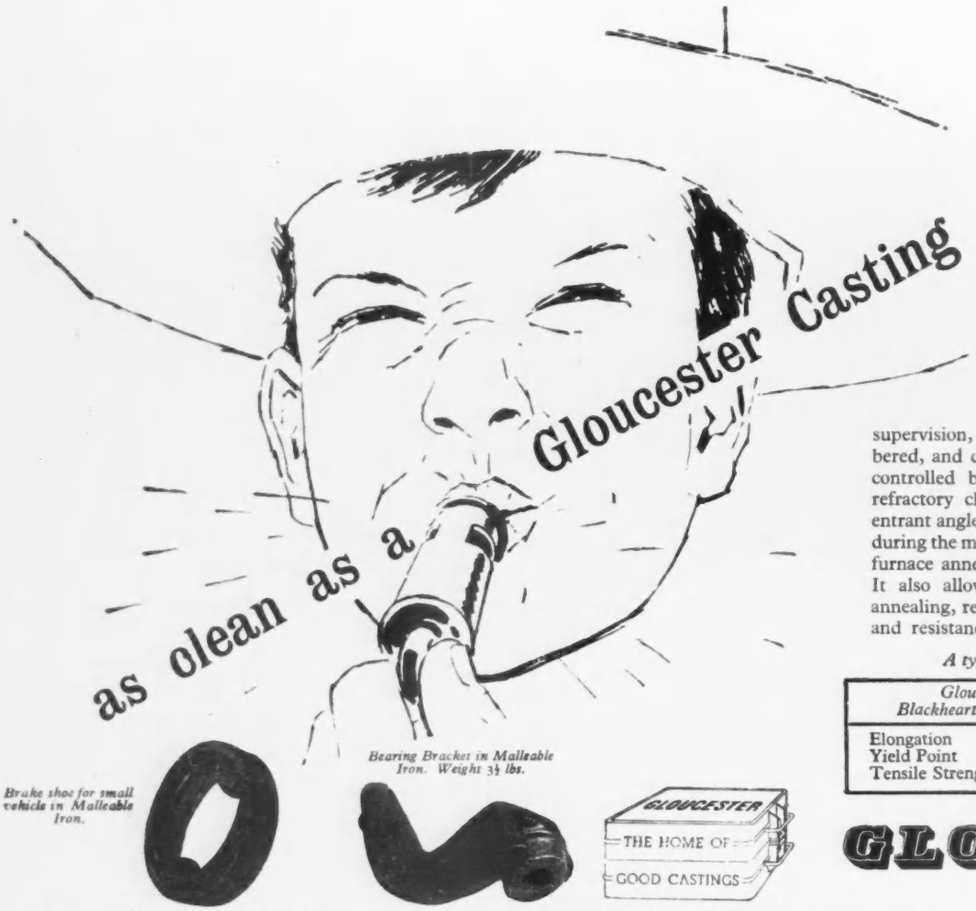

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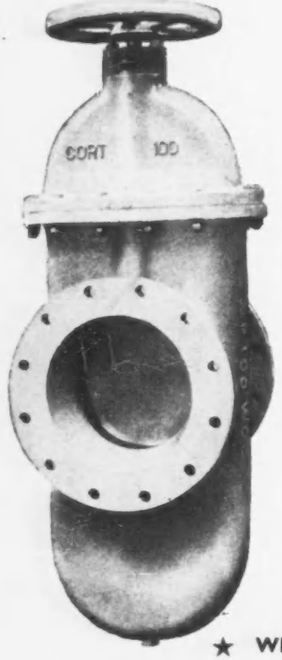

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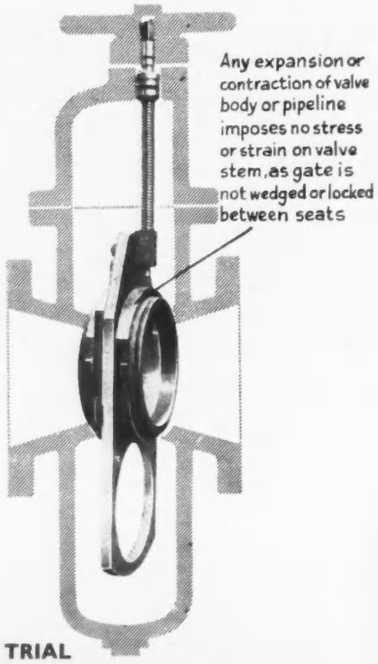
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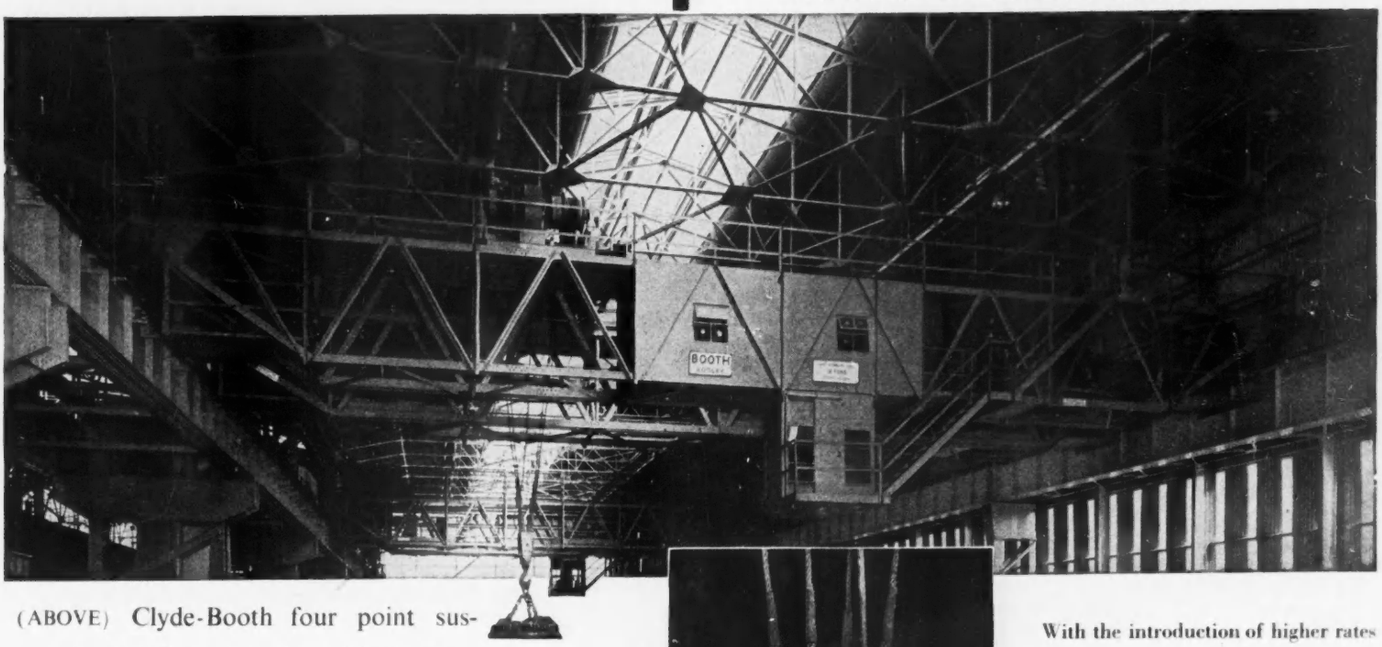
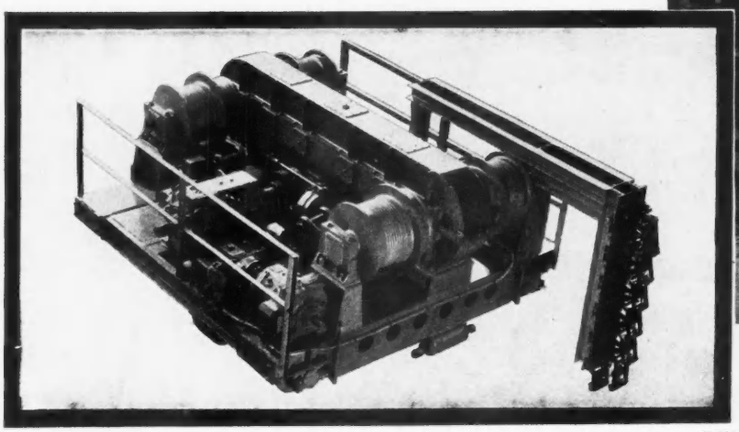


(ABOVE) Clyde-Booth four point suspension electric overhead travelling magnet crane at Messrs. Colvilles Ltd., Ravenscraig Works.
(RIGHT) The hook with slip-ring gear for the magnet, showing attachment of the four ropes.
(BELOW) The special four barrel crab.



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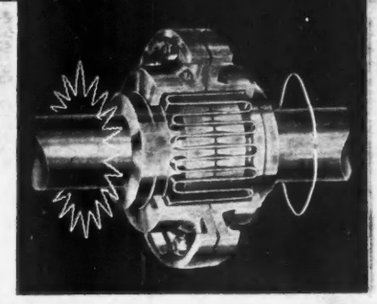

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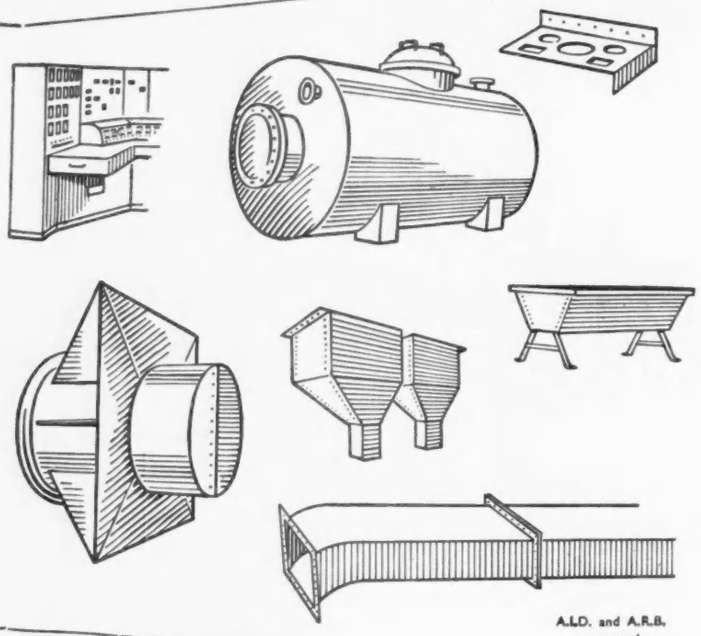

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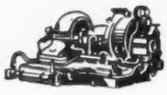

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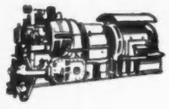

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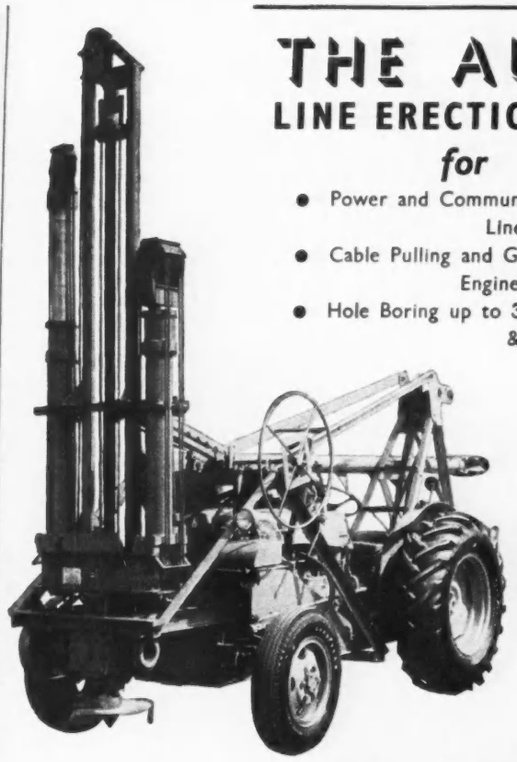

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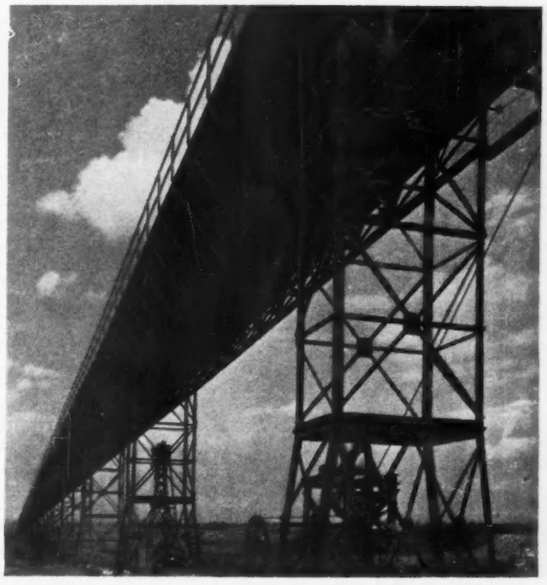

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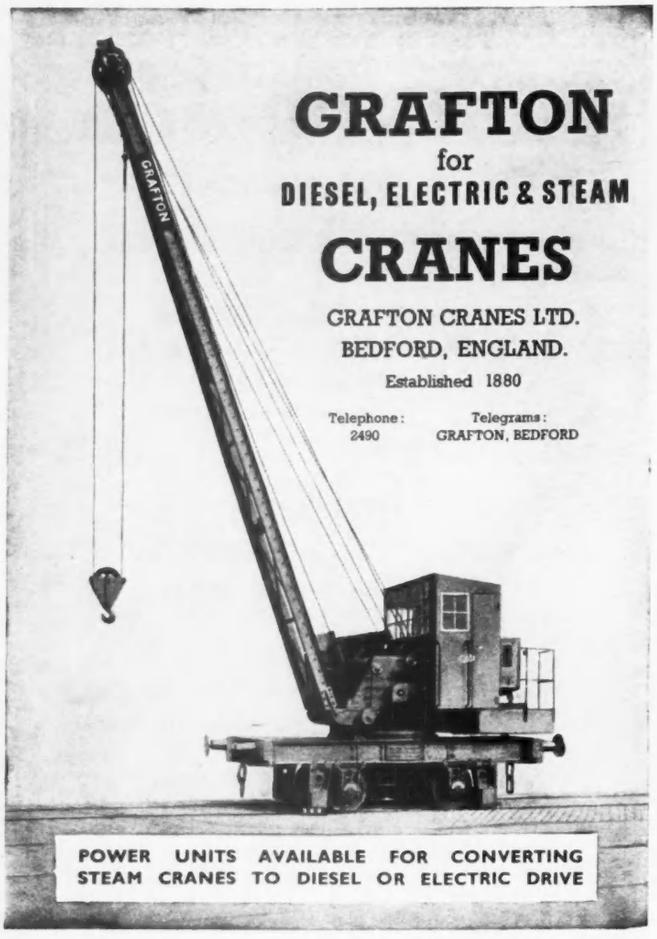

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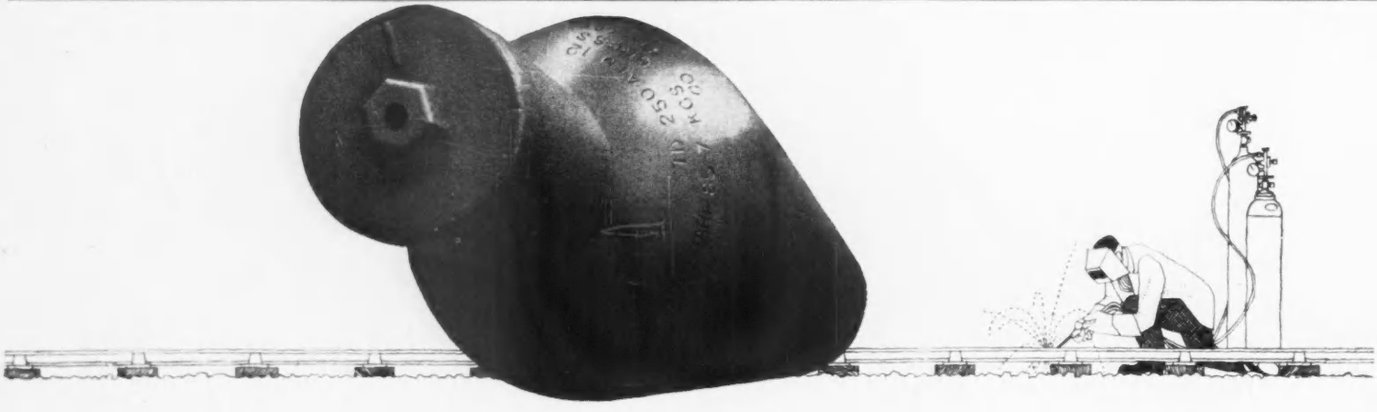

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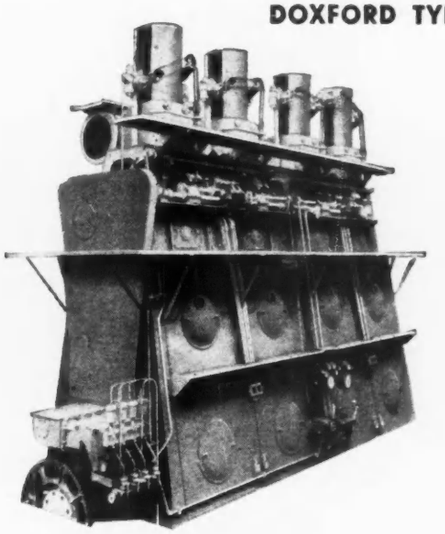
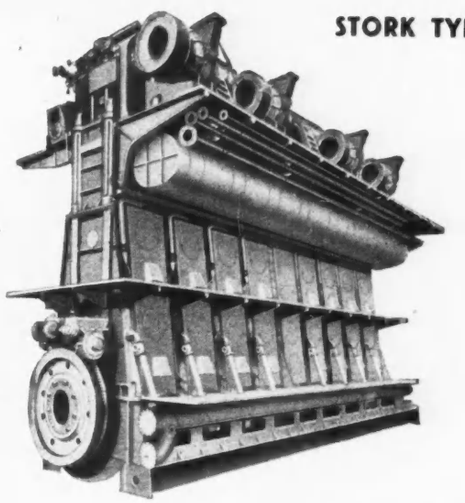


STORK TYPE



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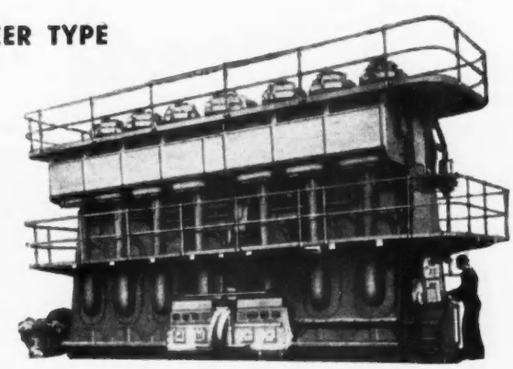

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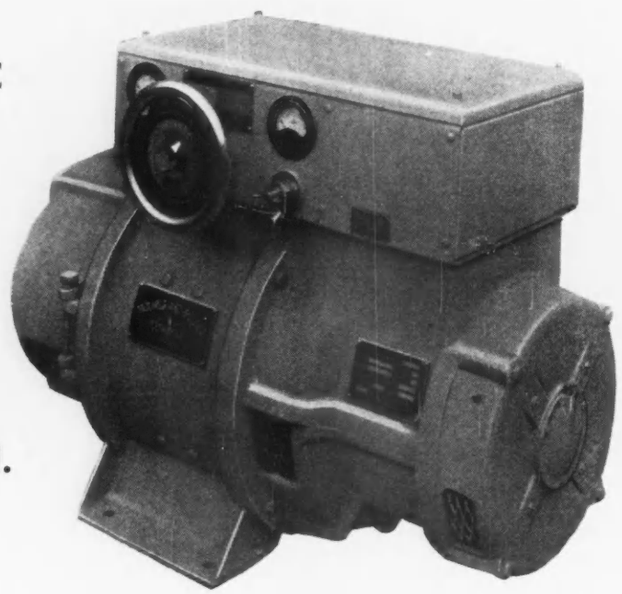

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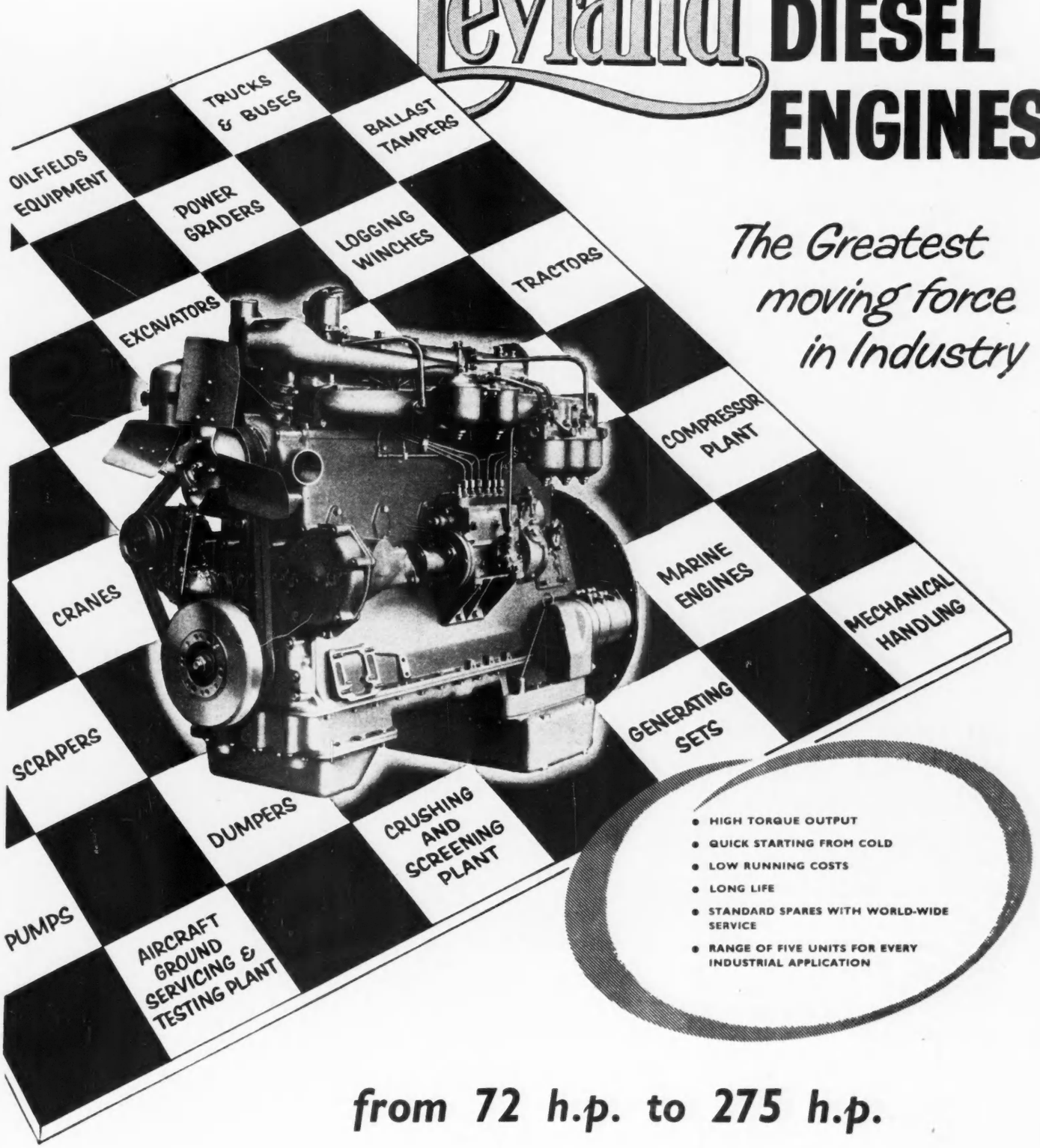

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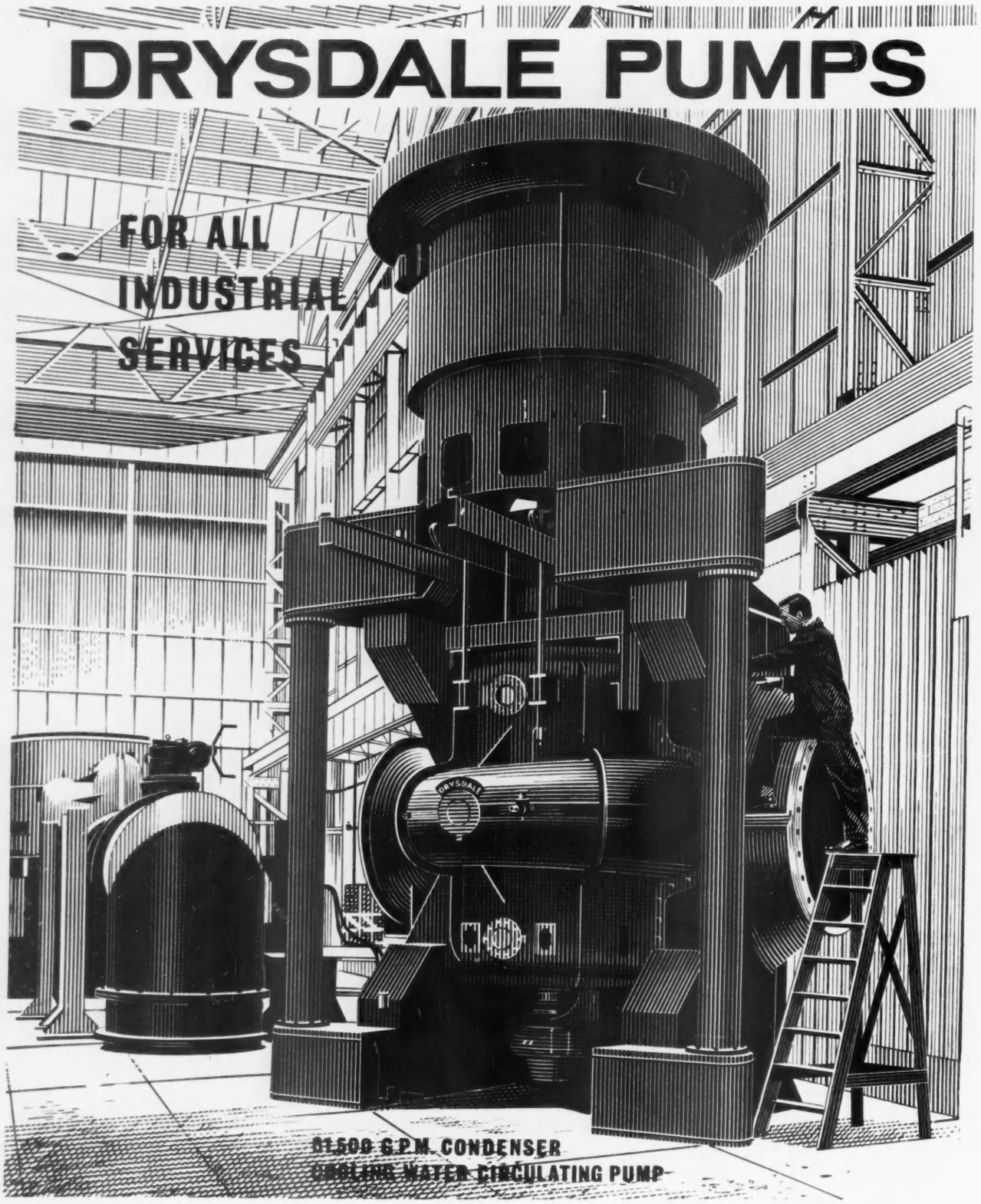

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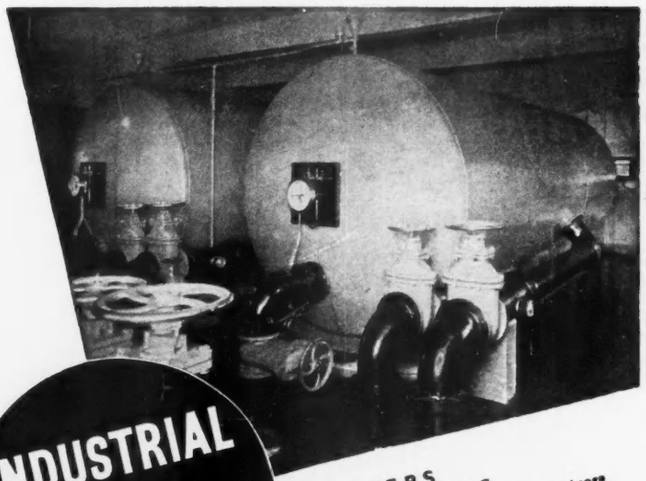

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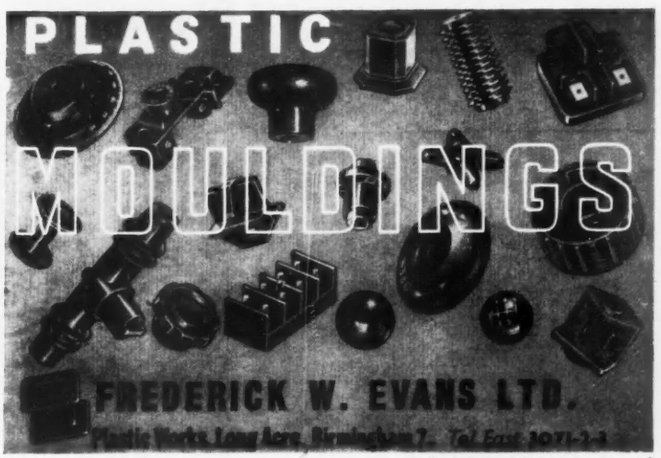

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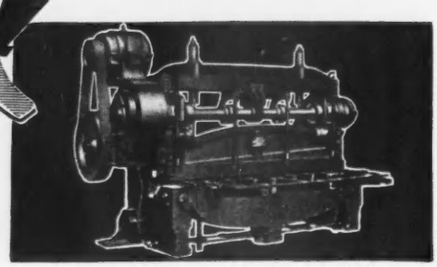

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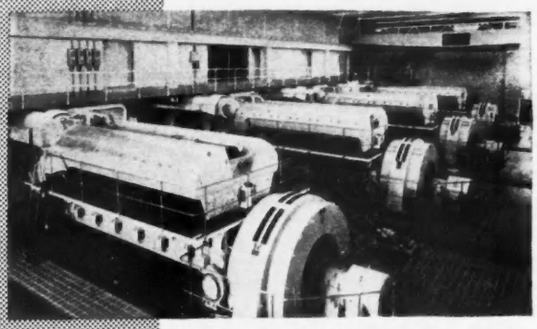
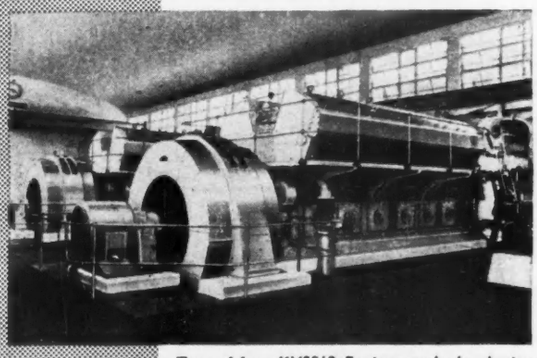


Four Mirrlees KVSS12 Engines each developing 3240 B.H.P./2250 kW at 450 r.p.m. Installed at John Street Pumping Station, Canada.



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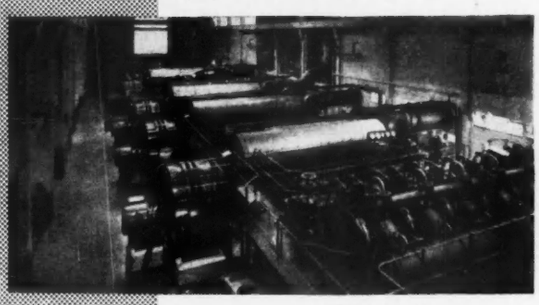

Seven Mirrlees KVSS12 1800 kW generating sets installed at the Jersey (Channel Islands) Power Station at St. Helier. A further two KVSS16 generating sets each developing 3000 kW are on order.

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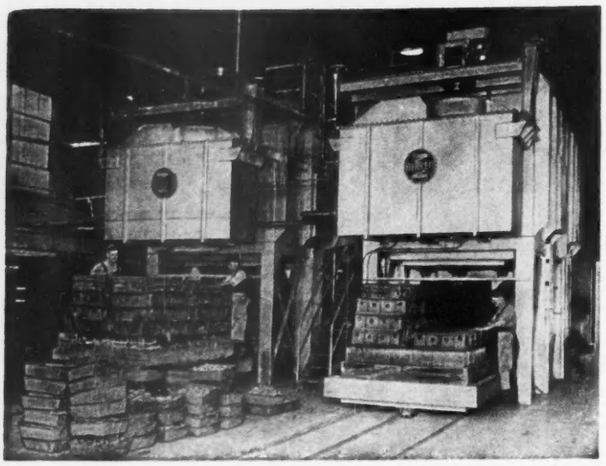

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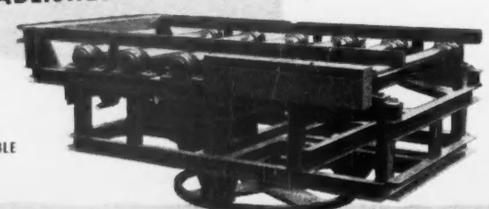

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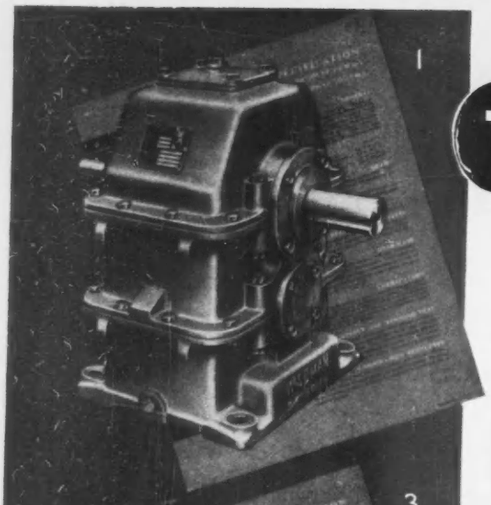

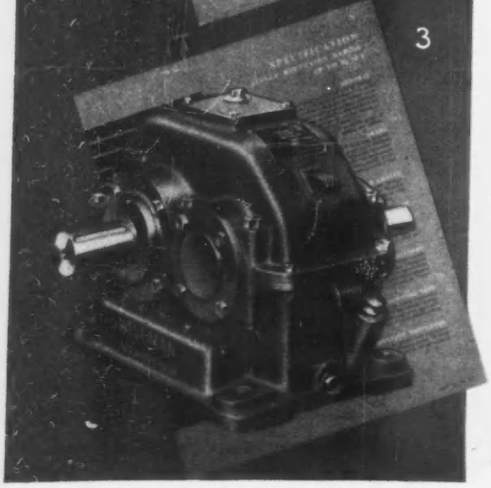

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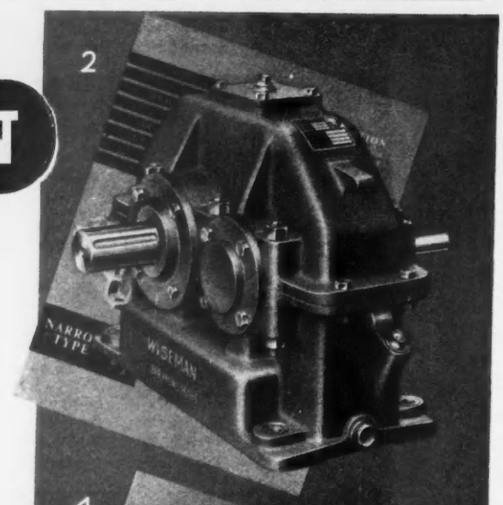

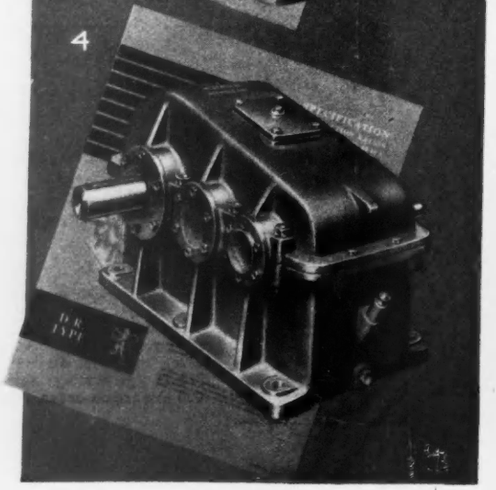

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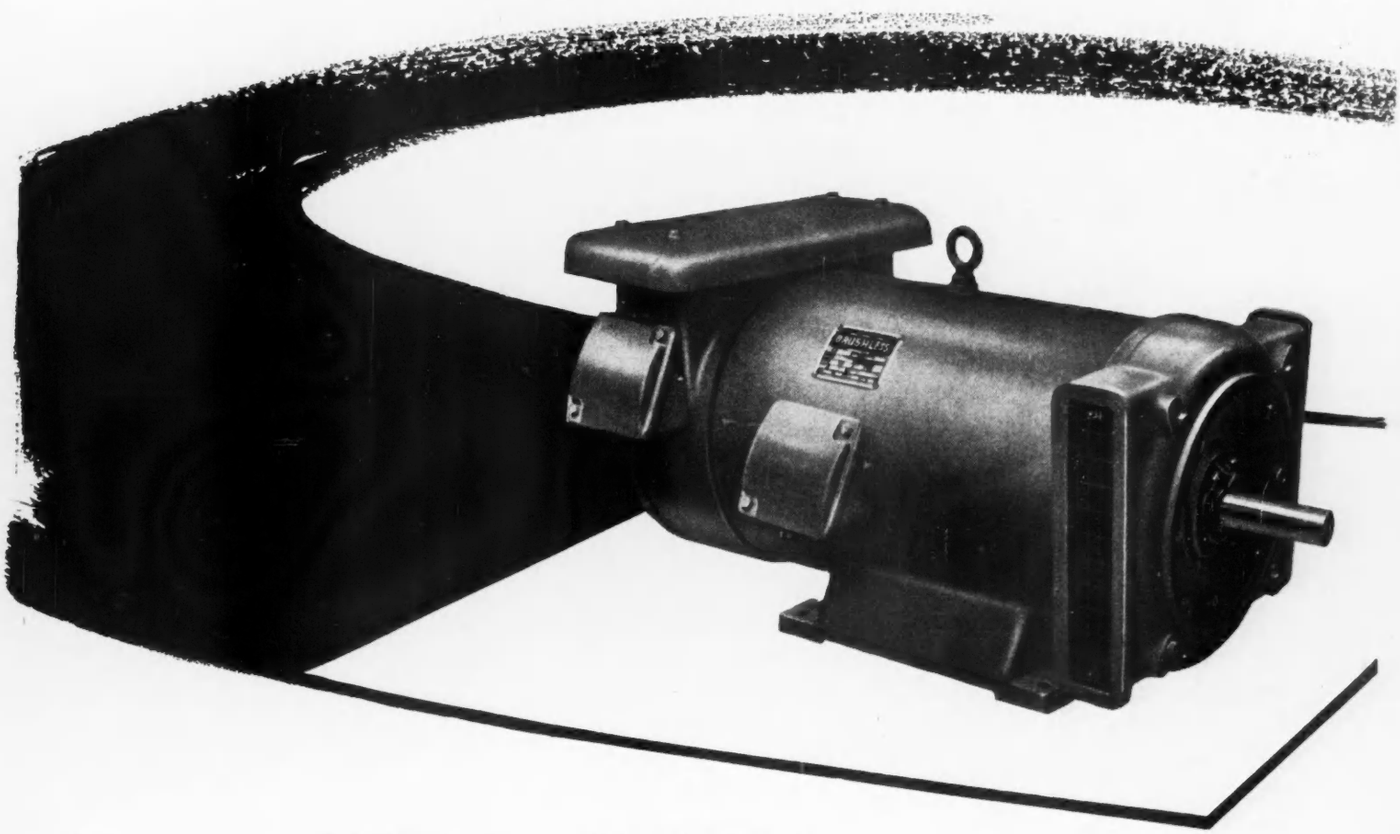

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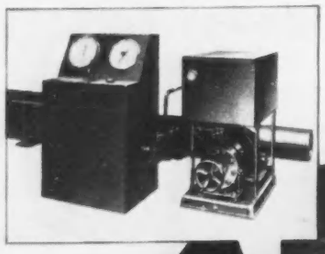
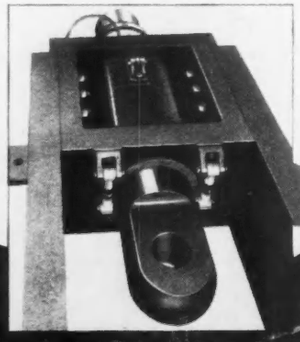
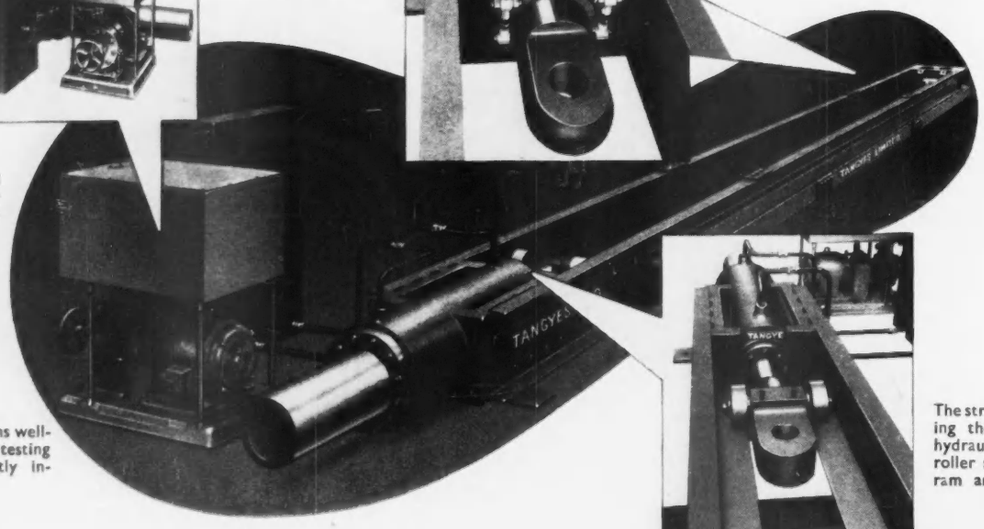


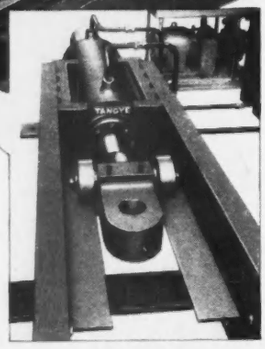
View from operating position showing control Cabinet and pump with oil reservoir.



The resistance head showing linkage support to eliminate friction. Hydraulic capsule and capillary tube also shown.



A Tangye 100 tons well-type chain testing machine recently installed.



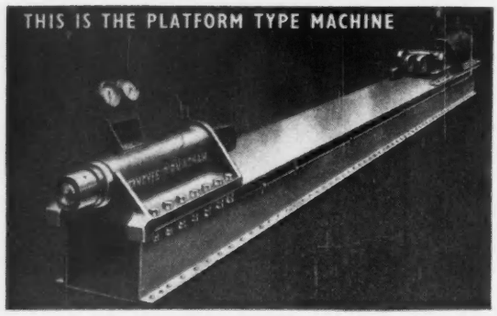
The straining end showing the double acting hydraulic cylinder and roller supports for the ram and tension rod.

This range of machines is for testing chains, shackles, complete lifting blocks, large rings and similar gear. One of the many features of these machines is the use of a tension rod which is suspended on links to take its weight and the weight of the specimen, thus preventing the rod contacting the bore and constituting a resistance. The pull being applied during a test is registered by a sensitive load capsule located on the tension rod, the capsule in turn being connected via capillary tubing to a dial-type load indicator.

Two types of machine are supplied, "Platform" or "Well" types, and these can be arranged for almost any working load, stroke or length. Examples of dimensions and capacities of machines now in use are shown in the table.

FULL INFORMATION IS AVAILABLE ON REQUEST.

THIS IS THE PLATFORM TYPE MACHINE



EXAMPLES OF CAPACITIES OF MACHINES NOW IN USE SHOWN BELOW

	Platform Type				*Well Type*			
Working Load. *In Tons* ...	50	75	75		15	30	50	100
Stroke of Straining End Piston. *In Inches*	36	36	36		30	30	30	36
Centres of Eye Ends on Tension Rods	30′	34′	16′		20′ 6″	30′ 6″	25′ 9″	51′

TANGYES LIMITED

SMETHWICK · BIRMINGHAM · Phone SME 1181

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Oldbury Chain Grate Stokers

ordered in the twelve months commencing 1st November 1959. Hire purchase terms are available from that date.

This offer is made in recognition of the national importance of maintaining a healthy coal industry and in support of the National Coal Board Campaign.

Proved by 17 years' successful operation, the Oldbury Stoker endorses the claim of the National Coal Board that coal, the home produced fuel, is competitive in price and performance with other fuels.

The Oldbury Stoker, the first successful chain grate stoker for shell boilers, was developed by Edwin Danks of Oldbury in 1942, with the prime object of burning efficiently low grade slacks, owing to the shortage of graded fuels. To-day, more than 6,000 Oldbury Stokers are in the service of industry, burning all sorts of solid fuel—

ECONOMICALLY by reducing fuel and labour costs.
SMOKELESSLY in compliance with the Clean Air Act.

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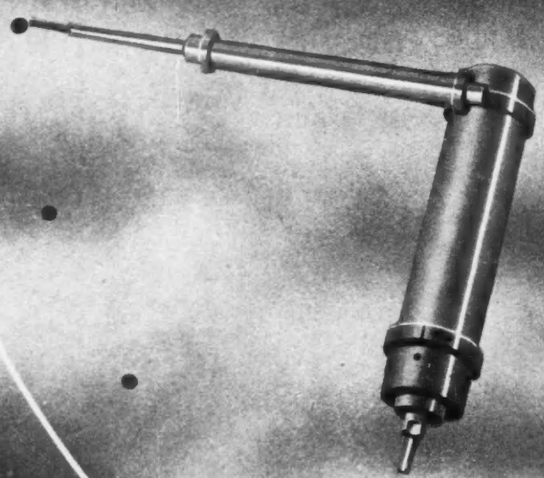
AIR CYLINDERS



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AN APPEAL for support for

The Delhi Engineering College Trust

The establishment of this Trust is part of a combined operation to provide buildings, staff and equipment for the new Delhi College of Engineering and Technology.

THE INDIAN GOVERNMENT is spending over £1,000,000 on *buildings*,

H.M. GOVERNMENT is spending £250,000 on *British staff*, from Colombo Plan funds, and

BRITISH INDUSTRY, in co-operation with the Institutions of Civil, Mechanical, Electrical and Chemical Engineers, has set up a Trust to administer a sum of at least £250,000 to be subscribed by members of the Federation of British Industries and other British Companies, to provide *equipment* for the College. The Trustees are Lloyds Bank Executor and Trustee Department, Threadneedle Street, London.

Why British Industry is Contributing

As His Royal Highness The Prince Philip said, when he laid the foundation stone of the College on the 27th January, 1959, this is firstly an example of friendly co-operation between two Commonwealth Governments ; and secondly, the raising by British Industry of a fund for equipment is a measure of the interest of independent companies in the United Kingdom in the technical progress of India. With such a background of sensible co-operation in such a worthy cause there is no doubt that this College will achieve great things. Engineers and technologists are greatly needed in India, to adapt the facts as they are uncovered by the scientists to the needs of the moment, with a proper understanding of the best interests of the community.

This shows the profound significance of the project. In Britain's friendly rivalry with the United States, Germany and the U.S.S.R. in equipping and staffing such colleges in India, the position is that, owing to the earlier participation of these Governments in such schemes, Colleges are now open and functioning fully in several important centres—other than at Delhi, the headquarters of the Indian Government, where the new College is to be established ; but on a recent visit to the United Kingdom Professor M. S. Thacker, Permanent Secretary of the Indian Ministry for Scientific Research and Cultural Affairs, confirmed that it is contemplated that the Delhi College shall become one of the principal institutions of its kind.

The scheme is therefore directed to the attainment of the highest objectives in Indian technical education and it is in recognition of the fundamental importance of this venture that Her Majesty's Government and British Industry are supporting it.

The following are the Sponsors of the Appeal, whose Companies have already contributed, or have promised contributions under covenant :

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£70,000 is still needed

May the name of your Company be added to those listed above, to be shown in the permanent record in the Delhi College of the British contributors to the equipment of the College?

If you will join in this important project, please write to Sir Eric Coates, C S I, C I E, Chairman of the Executive Committee of the Trust, at Bowater House, Knightsbridge, London, S W 1, and he will provide all the information that you may require to make a contribution by a lump sum or by a payment under seven years' covenant so that income tax on the donation may be recovered.

W. H. MCFADZEAN

President of the Federation of British Industries

Chairman of the Sponsors of the Trust

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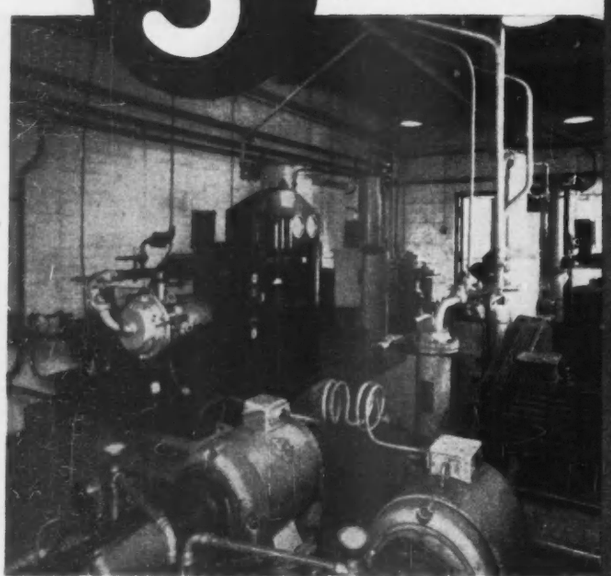
INERT GAS

at 3/- per 1,000 cubic feet.



Two Holmes-Kemp Inert Gas Generators installed at the Speke Works, Liverpool, of Messrs. Beck Koller & Co. (England) Ltd. Each of these machines is capable of producing 3,000 cubic feet of gas per hour.

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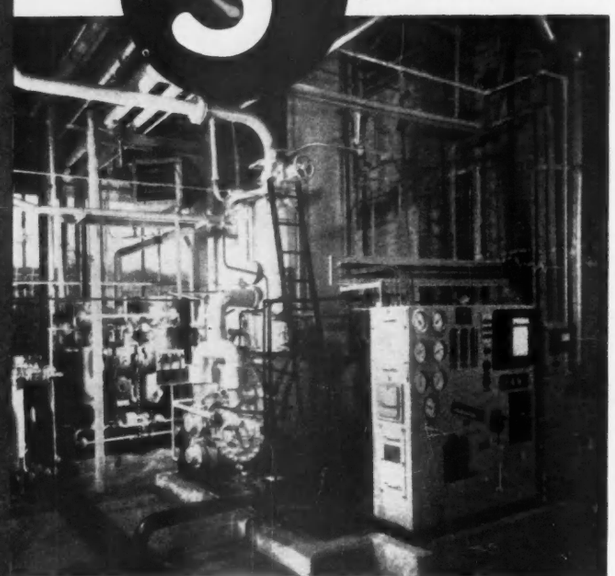

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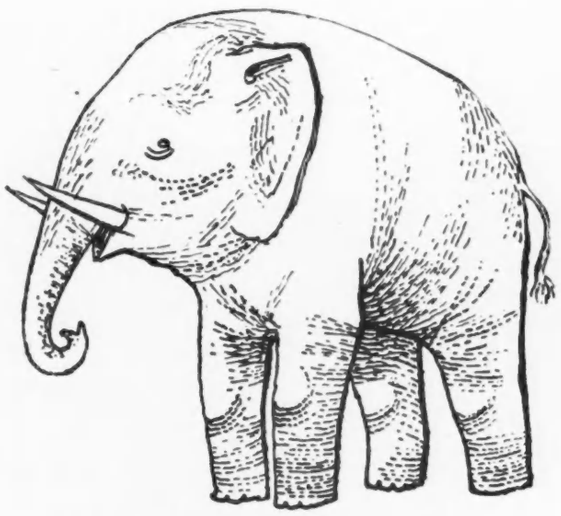

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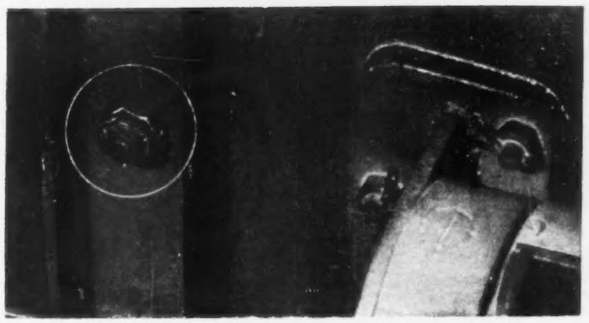

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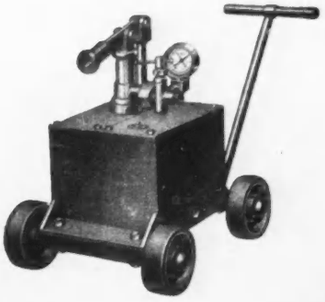

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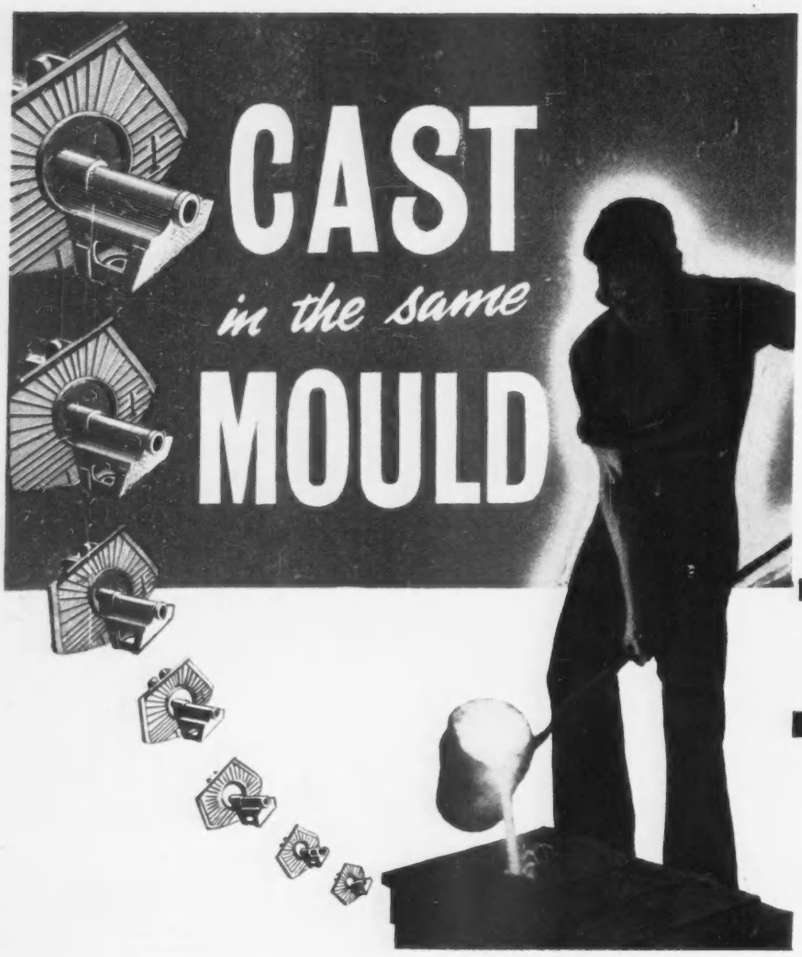

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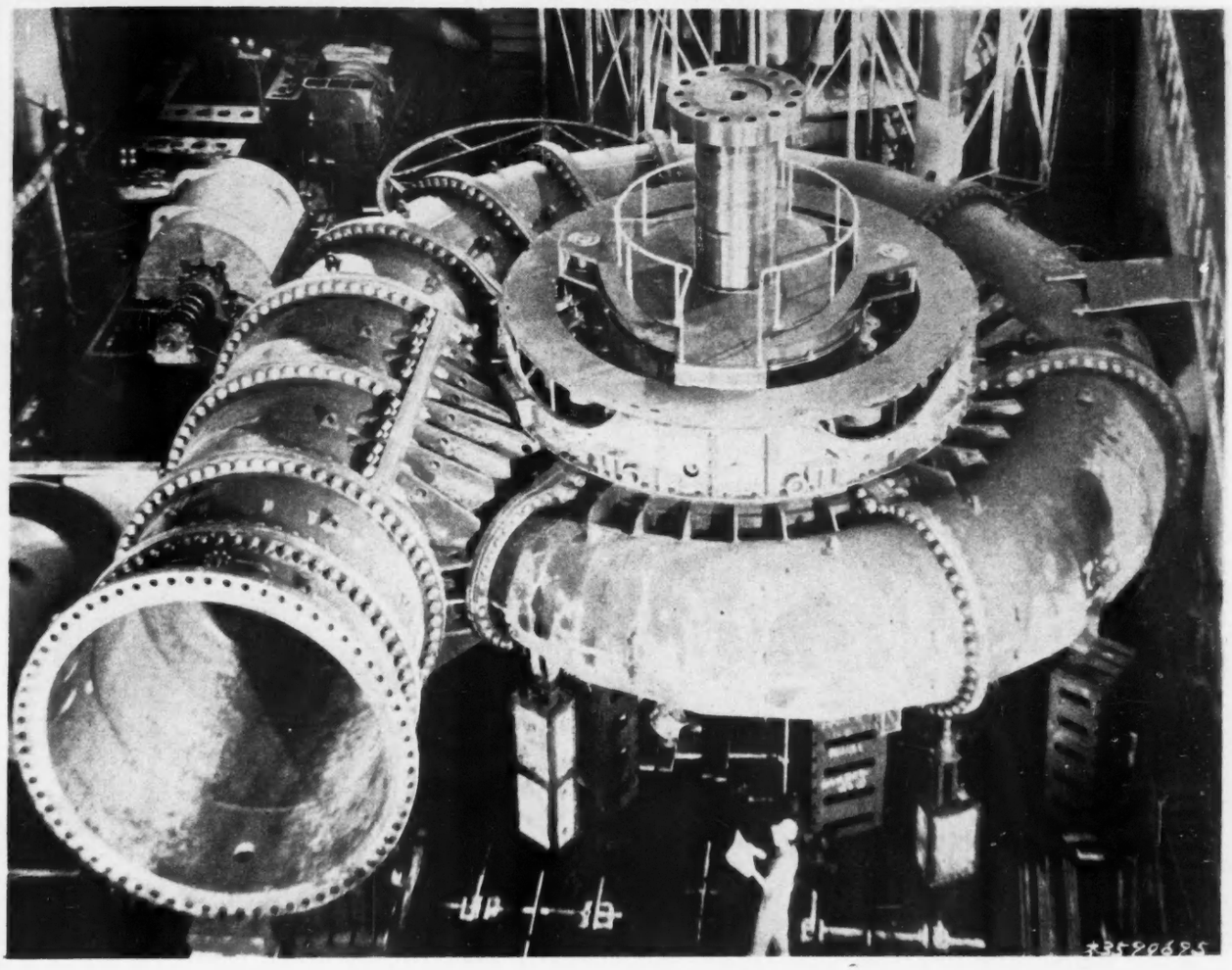
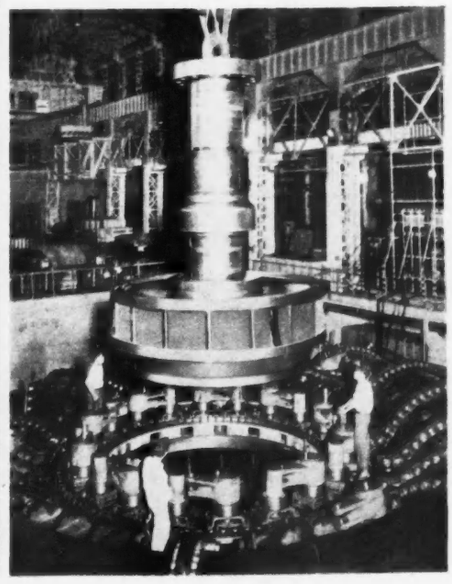
HITACHI



Another big Francis Turbine by Hitachi



The completion of yet another big Hitachi job was recently marked by the successful factory tests of a 137,500 kW Francis Turbine. This is the first of a pair to be built, together with two 125,000 kVA generators for the Miboro Power Station in Central Japan.

This vertical-shaft Francis turbine is specified for a speed of 225 rpm, a maximum effective head of 200 m and 76.6 m^3/sec water flow, making it one of the largest units of its kind in the world. Its runner has a maximum diameter of 3.7 m and the main shaft a diameter of 95 cm. The spiral casing, which was constructed in 13 sections to facilitate transportation to the site, has an inlet diameter of 3.35 m and an outer diameter of 11.2 m.

Hitachi, Ltd.
Tokyo Japan

Cable Address : "HITACHY" TOKYO

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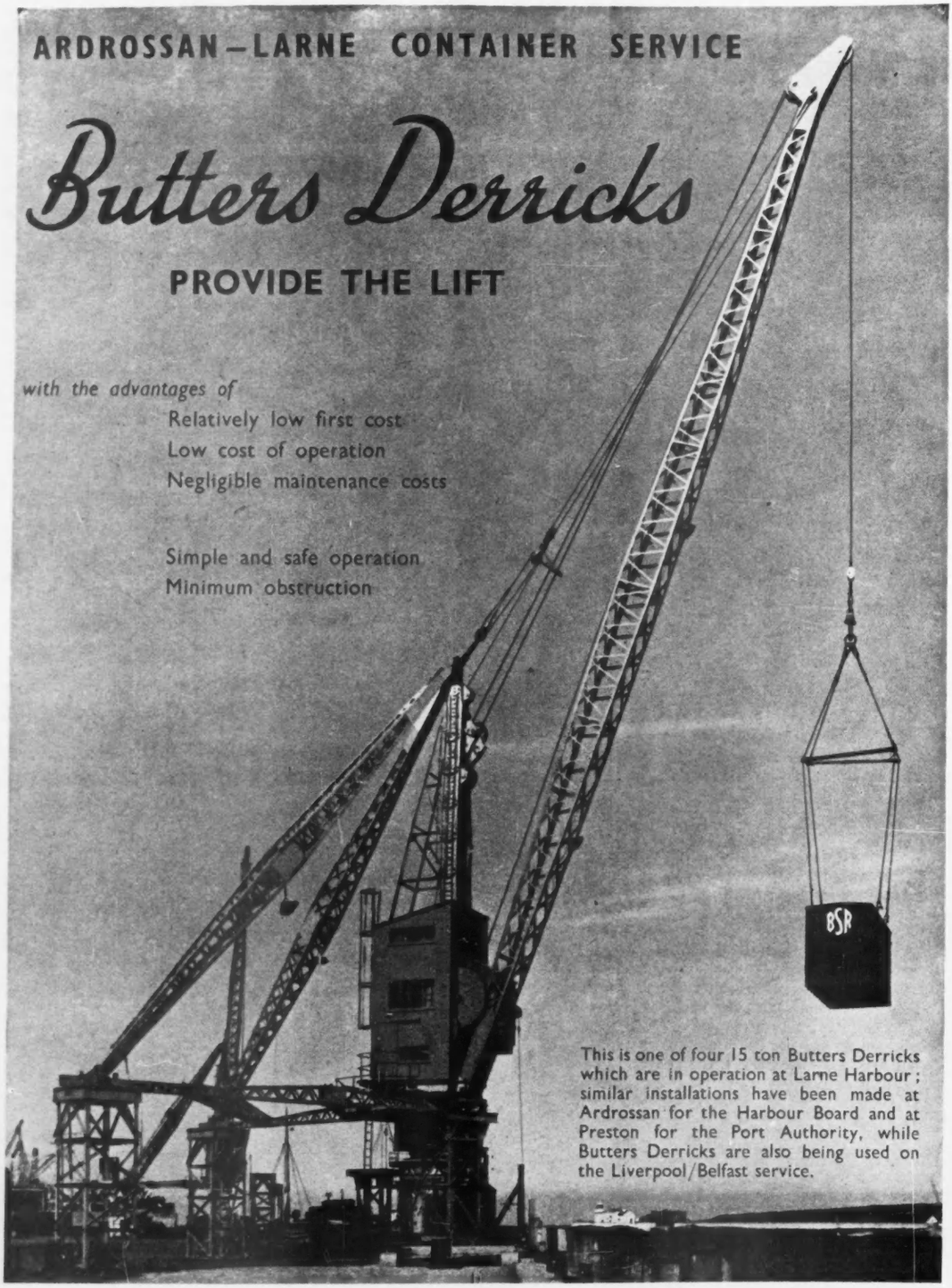
ARDROSSAN—LARNE CONTAINER SERVICE
Butters Derricks
PROVIDE THE LIFT
with the advantages of
Relatively low first cost
Low cost of operation
Negligible maintenance costs
Simple and safe operation
Minimum obstruction
BSR
This is one of four 15 ton Butters Derricks which are in operation at Larne Harbour; similar installations have been made at Ardrossan for the Harbour Board and at Preston for the Port Authority, while Butters Derricks are also being used on the Liverpool/Belfast service.

DERRICK CRANES OF 45 TONS CAPACITY OR MORE

are now being produced to meet a demand for essentially simple and completely reliable cranes for the heavy duties involved in nuclear power station construction and elsewhere.

We will be pleased to quote against requirements

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LONDON: THE CRANE WORKS, LONG LANE, HILLINGDON, M'sex.
AND AT BIRMINGHAM AND NEWCASTLE

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Use of Box Number. 2/- which includes forwarding of replies.

Copy Dates. Tuesday for publication on Friday of the same week. If proofs are wanted, copy is required on Thursday for publication on Friday of the following week.

***Advertisements for publication should be addressed to*:—Classified Advertisement Dept., "THE ENGINEER," 28 Essex Street, Strand, London, W.C.2**

Urgent advertisements may be telephoned to CENtral 6565.

PUBLIC APPOINTMENTS

BRADFORD INSTITUTE OF TECHNOLOGY

Principal : E. G. EDWARDS, Ph.D., B.Sc., F.R.I.C.

SENIOR LECTURER IN MECHANICAL ENGINEERING AND LECTURER IN MECHANICAL ENGINEERING

Applications are invited for the posts of SENIOR LECTURER IN MECHANICAL ENGINEERING and LECTURER IN MECHANICAL ENGINEERING.

Candidates should be well-qualified and industrial and research experience would be a recommendation. The successful candidates will be required to teach one or more subjects to Honours Degree standard. They will be encouraged to undertake research and adequate facilities will be available.

Salary scales : Senior Lecturer, £1550–£1750 per annum ; Lecturer, £1370–£1550 per annum.

Previous industrial and research experience at a suitable level may be taken into account in fixing the commencing salary.

Further particulars and forms of application may be obtained from the Registrar, Bradford Institute of Technology, Bradford, 7.

W. H. LEATHEM,
Clerk to the Governors.

E8318

BRADFORD INSTITUTE OF TECHNOLOGY

Principal : E. G. EDWARDS, Ph.D., B.Sc., F.R.I.C.

READER IN MECHANICAL ENGINEERING

Applications are invited for the post of READER IN MECHANICAL ENGINEERING.

Candidates should possess the qualifications and experience to direct research and post-graduate work, and to take a leading part in advanced teaching. Importance will be attached to industrial and research experience. Adequate facilities will be given to undertake research and suitable technical assistance and equipment are available. Staff are encouraged to develop industrial contacts and to undertake consultant work in industry and may retain fees paid for such work.

Salary scale : £1800 to £2100 per annum.

Previous industrial and research experience at a suitable level will be taken into account in fixing the commencing salary.

Further particulars and forms of application may be obtained from the Registrar, Bradford Institute of Technology, Bradford, 7.

W. H. LEATHEM,
Clerk to the Governors.

E8317

CARMARTHEN MENTAL HOSPITAL MANAGEMENT COMMITTEE

ST. DAVID'S HOSPITAL AND PANTGLAS HALL

SUPERINTENDENT ENGINEER

Applications are invited for the post of SUPERINTENDENT ENGINEER from candidates holding any of the following certificates : Ministry of Transport and Civil Aviation (ex Board of Trade) First Class Certificate of Competency in Marine Engineering : Ministry of Transport and Civil Aviation Certificate of Service as First Class Engineer : City and Guilds full Technological Certificate in Plant Engineering (First Class). A sound knowledge of the principles and practices of the efficient operation and maintenance of modern institutional boiler plant and engineering services, including electrical, is essential.

Salary : £890–£1045.

An unfurnished house will be available on the estate for which a moderate rent will be charged.

The appointment is subject to the National Health Service (Superannuation) Regulations, and the successful candidate, if not a transferable officer, will be required to pass a medical examination.

Applications, stating age, qualifications, experience and present position, together with the names of three referees who can testify to professional ability, to be sent to the Secretary, St. David's Hospital, Carmarthen, not later than December 31st.

E8281

PUBLIC APPOINTMENTS

BRADFORD INSTITUTE OF TECHNOLOGY

Principal : E. G. EDWARDS, Ph.D., B.Sc., F.R.I.C.

PRINCIPAL LECTURER IN MECHANICAL ENGINEERING

Applications are invited for the position of : PRINCIPAL LECTURER IN MECHANICAL ENGINEERING.

Candidates should be qualified to teach to final degree standard preferably in Thermodynamics and Mechanics of Fluids and should have had adequate industrial experience.

The successful candidate will be expected to assist the Head of the Department with the administrative work of the Department and will be encouraged to develop industrial contacts.

Salary scale : £1750 to £1900 per annum.

Previous industrial and research experience, at a suitable level, will be taken into account in fixing the commencing salary.

Further particulars and forms of application may be obtained from the Registrar, Bradford Institute of Technology, Bradford, 7.

W. H. LEATHEM,
Clerk to the Governors.

E8326

GOVERNMENT OF CEYLON

DEPARTMENT OF AGRICULTURE

ENGINEERS

Applications are invited from suitable qualified candidates to fill the following three vacancies in Ceylon.

(i) MECHANICAL ENGINEER, should be A.M.I.Mech.E. with 5 years' practical mechanical engineering workshop experience. Should have experience of repair and maintenance of heavy tractors, motor vehicles and allied equipment.

(ii) ELECTRICAL or MECHANICAL ENGINEER, should be A.M.I.Mech.E. and/or A.M.I.E.E., with 5 years' or more practical experience in a mechanical and/or electrical repair workshop. Should be able to undertake repair and maintenance of Diesel Electric generating plant, Refrigeration Plant, Audio-Visual Aids, &c.

(iii) CIVIL ENGINEER, B.Sc. an advantage, A.M.I.C.E. essential. Should have at least 5 years' experience of design and construction of buildings in concrete and steel, road construction and maintenance, earthworks.

Candidates for the above posts should be not less than 35 years of age on 1st October, 1959, be of excellent moral character and physically sound.

Candidates should have first-class administrative experience and ability.

Terms of Engagement : The appointments will be for 3 years in the first instance on a Provident Fund basis.

Salary : For Europeans, £1200 by £50 to £1500 per annum. For Indians and Pakistanis, Rs.15600 by Rs. 600 to Rs. 18,000.

Further particulars concerning allowances, quarters, passages, &c., and forms of application may be obtained on application to the High Commissioner for Ceylon.

Applications on the prescribed form should reach the High Commission for Ceylon, 13, Hyde Park Gardens, London, W.2, on or before 13th January, 1960.

E8322

ROYAL BUCKINGHAMSHIRE AND ASSOCIATED HOSPITALS MANAGEMENT COMMITTEE

SUPERINTENDENT ENGINEER

SUPERINTENDENT ENGINEER required for five hospitals, totalling 565 beds, to be responsible for all engineering services and to co-operate with the Group Building Superviser, who is responsible for building maintenance. Applicants must have passed an examination in engineering technology and hold an approved qualification.

Salary scale in 20½–30 points group, i.e. £890 to £1045 per annum (increase pending). House available.

Further details available from the Secretary, 9, Bicester Road, Aylesbury, to whom applications, stating full details of qualifications, age and experience, and naming three referees, should be sent by 12th January, 1960.

E8314

PUBLIC APPOINTMENTS

GUILDFORD, GODALMING AND DISTRICT WATER BOARD

APPOINTMENT OF SENIOR ENGINEERING ASSISTANT

Applications are invited for the appointment of SENIOR ENGINEERING ASSISTANT at a salary in accordance with Grade A.P.T. II (£765–£880 per annum).

Candidates should have had good experience in the general engineering work of a Water Undertaking, and have passed part of the Associate Membership Examination of the Institution of Civil Engineers.

The appointment will be subject to the National Scheme of Conditions of Service, the Local Government Superannuation Acts, and to the passing of a medical examination.

Applications, stating age, training, present and previous appointments and experience, and names and addresses of two referees, must be received by the Chief Engineer, "Branksome," Filmer Grove, Nightingale Road, Godalming, not later than Monday, 11th January, 1960.

Housing accommodation will be available for a married man.

H. C. WELLER,
Clerk to the Board.

Municipal Offices,
High Street,
Guildford.

E8319

CENTRAL ELECTRICITY GENERATING BOARD

MIDLANDS PROJECT GROUP

SENIOR DRAUGHTSMAN (MECHANICAL)

Applications are invited for the appointment of SENIOR DRAUGHTSMAN (MECHANICAL) in the Midlands Project Group at Moseley, Birmingham, in the first instance, moving to Bournville by approximately March, 1960.

Applicants should have received a sound technical training and should preferably have served an apprenticeship in Mechanical Engineering followed by some experience in the preparation of drawings associated with power station plant. Possession of a Higher National Certificate will be an advantage.

The salary will be in accordance with Schedule D, Grade 5 (£790–£890 per annum), or Grade 4 (£930–£1030 per annum) of the N.J.B. Agreement, according to the duties and responsibilities of the post.

Applications should be made on standard form AE6, available from the Administrative Officer, Midlands Project Group, 53, Wake Green Road, Moseley, Birmingham, 13, and should be returned to him not later than 1st January, 1960.

Envelopes should be marked "Confidential Staff Vacancy Notice No. MPG.142/59." E8315

TENDERS

N.A.T.O. COMMON INFRASTRUCTURE

SLICES VII AND VIII

NAVAL BASE INSTALLATIONS

Final Notice is hereby given that International Competitive BIDS will be invited on or about 17th February, 1960, for the SUPPLY and INSTALLATION of the BOILER PLANT and Associated Equipment for a P.O.L. Storage Depot to be constructed in the Loch Striven area of Scotland.

(2) The approximate total value of the works is £60,000 and the contract will comprise of the Supply and Installation of :—

3 (No.) 13,000 lb. per hour each Economic type Oil-fired Boilers, complete with Superheaters and full ancillary equipment, including Fuel Oil System, Feeder Water System, Water Treatment, De-superheater, Induced Draft Fans, Station Pipe Work, &c.

(3) The work will be carried out as one contract which will be undertaken as a sub-contract within the framework of the Main Contract for the construction of the depot. A Final Notice in respect of the main construction contract has already been published.

(4) It should be noted that the importation of labour from sources outside the United Kingdom may be subject to restriction and that permission could, in any case, only be given on an undertaking that the Contractor would pay rates of wages and absence hours and conditions of labour not less favourable than those established for U.K. labour for the trade or industry in the same area.

(5) The closing date for the receipt of Bids will be 13th April, 1960.

(6) Firms wishing to be invited to Bid must formally notify their desire by application to the address below by 13th January, 1960.

(7) Within one week of the closing date for the receipt of applications to Bid, firms wishing to be invited must forward the following information :—

(i) Statement of financial resources and evidence of financial stability.

(ii) Details of recent major contracts completed for work of a comparable nature, including an indication of the value of each.

(8) Enquiries regarding bidding should be addressed to :—

Civil Engineer-in-Chief,
Admiralty,
Chamberlain Way,
Pinner, Middlesex, England,

quoting reference C.E. in C./INFRA/9 (Sub-Contract Boilers). E8308

EDUCATIONAL

A.M.I.MECH.E., B.Sc., City and Guilds, etc., Guarantee Postal Courses for all Exams. and Technical Divisions from Elementary to Degree standard including Automation Techniques. Approximately 95 per cent successes. 148-page prospectus free, on request.—B.I.E.T. (Dept. 22), 29, Wright's Lane, London, W.8. E114 E

NORTHAMPTON COLLEGE OF ADVANCED TECHNOLOGY

ST. JOHN STREET, LONDON, E.C.1.

DIRECTION AND SUPERVISION OF SCIENTIFIC AND ENGINEERING PERSONNEL : A PRACTICAL COURSE IN HUMAN RELATIONS FOR SENIOR MANAGERS.

This course is meant for senior managers, especially those concerned with research or development, and it is based on a new approach to training.

The Purpose of the Course The purpose of the course is to increase effectiveness in the supervision of scientific and engineering personnel—and in organising their work so that their technical knowledge and abilities may be used to the full—by recognising the specific problems in this field and by appreciating the role of individual personality and outlook in allotting duties and defining areas of responsibility.

Method of Instruction This purpose will be achieved through discussion of real life case studies in human relations, and by extending theoretical knowledge of human behaviour relevant to these situations. The characteristic feature of the course is its practical nature.

The course consists of twelve full days' meetings, held at fortnightly intervals, from 20th January to 6th July, 1960, inclusive. In view of the limited membership, nominations should be sent in as soon as possible. Further particulars from the Secretary, Northampton College of Advanced Technology, St. John Street, London, E.C.1.

E8320 E

TENDERS

N.A.T.O. COMMON INFRASTRUCTURE

SLICES VII AND VIII

DEVELOPMENT OF AN EXISTING NAVAL AIR STATION

FINAL NOTICE is hereby given that International Competitive BIDS will be invited on or about the 10th March, 1960, for the undermentioned ELECTRICAL INSTALLATION work in connection with the extension of the runway, &c., at the existing airfield at Machrihanish, Argyll, Scotland.

(a) Airfield Lighting Installation including Runway and Approach Systems.
(b) Extensions to the High Voltage and Medium Voltage Cable Installations.
(c) Connecting up of Cables, Switchgear, Transformers, &c., in Substations, Electric Light and Power in substations and Control Building.

(2) The work is to be undertaken as one contract which will be carried out as a sub-contract within the framework of the main civil engineering contract for Stage One of the development of the airfield.

(3) The approximate total value of the sub-contract is £105,000.

(4) It should be noted that the importation of labour from sources outside the United Kingdom may be subject to restriction and that permission could in any case be granted only on an undertaking that the Contractor would pay rates of wages and observe hours and conditions of labour not less favourable than those established for the United Kingdom labour for the trade or industry in the same area.

(5) The closing date for the receipt of Bids will be 20th May, 1960.

(6) Firms wishing to be invited to bid must formally notify their desire by application to the address below by 3rd February, 1960.

(7) Within one week of the closing date for receipt of applications to bid, firms wishing to be invited must forward the following information :
(i) Statement of financial resources and evidence of financial stability.
(ii) Details of recent major contracts completed for work of a comparable nature including an indication of the value of each.

(8) Enquiries regarding bidding should be addressed to :—

Civil Engineer-in-Chief,
Admiralty,
Chamberlain Way,
Pinner,
Middlesex, England,

and quoting reference C.E. in C./INFRA/7 (Electrical Sub-Contract). E8328

MINISTRY OF TRANSPORT

LONDON-FISHGUARD ROAD A.40 WESTERN AVENUE A.40-JUNCTION WITH HANGER LANE WESTERN AVENUE UNDERPASS

SUB-CONTRACT FOR INSTALLATION OF ELECTRIC LIGHTING

TENDERS are invited from established electrical contractors, who can provide evidence to show that they have successfully carried out previous similar contracts, for the INSTALLATION of the ELECTRIC LIGHTING SYSTEM required for illumination of the tunnels, approach ramps and pedestrian subways being constructed in connection with the above project.

Copies of the Sub-Contract documents and drawings may be obtained from the main contractor for the works, A. E. Farr, Ltd., of Station Road, Westbury, Wilts., on receipt of a deposit of £15 which will be refunded on submission of a bona fide Tender that is not subsequently withdrawn.

Completed Tenders must be delivered to the Engineer for the Works, Rendel, Palmer and Tritton, Chartered Civil Engineers, 125, Victoria Street, London, S.W.1, in a plain, sealed envelope endorsed "Western Avenue Underpass—Tender for Installation of Electric Lighting," not later than 10 a.m. on 14th January, 1960.

No guarantee can be given that the lowest or any Tender will be accepted. E8313

SITUATIONS VACANT

APPLICANTS ARE ADVISED TO SEND COPIES NOT ORIGINALS OF THEIR TESTIMONIALS UNLESS OTHERWISE REQUESTED.

AN EXPERIENCED SENIOR ESTIMATOR required, accustomed to preparing works costs and selling prices of machine tool type products (medium to heavy) from design information.—Apply BOX No. E8323, "The Engineer." A

APPLICATIONS ARE INVITED from ambitious and resourceful men to fill the position of TECHNICAL ASSISTANT to the Sales Manager of Electric Lamp Machinery Manufacturers near London. A permanent, progressive and interesting job is offered to the right person, who must possess a sound engineering and commercial background in the trade.—Applications, with full particulars of education, experience and salary required to BOX No. E171, "The Engineer." A

CHIEF ENGINEER required for progressive medium-sized Company specialising in aircraft and other light engineering equipment. Excellent prospects for fully qualified man with the right experience. —BOX No. E2659, "The Engineer." A

DESIGN ENGINEERS with from one to seven years' experience in design of heavy reinforced concrete work, steel and concrete structures, bridges, hydro-electric work, &c. Also DESIGN-DRAUGHTSMEN and DRAUGHTSMEN.—Apply in writing to Sir William Halcrow and Partners, Alliance House, Caxton Street, London, S.W.1. E8316 A

SITUATIONS VACANT

DESIGNER DRAUGHTSMAN required, preferably with H.N.C. in Mechanical Engineering. Non-Contributory Pension Scheme available.—Applications to Metalectric Furnaces, Ltd., Cornwall Road, Smethwick, 40, Staffs. E2662 A

DRAUGHTSMEN required in Technical Department of first-class engineering company of repute in Newark, pension scheme, &c. State age, experience, qualifications and salary required.—BOX No. E8311, "The Engineer." A

MECHANICAL ENGINEER with senior status required for research and development work in Manchester. Honours Degree, good knowledge of thermodynamics metallurgy and experience with design calculations of various kinds of thermal plant essential.—Apply, Kennedy and Donkin, 12, Caxton Street, London, S.W.1, or 64, Royal Exchange Manchester. E8309 A

PROJECT ENGINEERS.—The Stanton Ironworks Company, Limited, near Nottingham, has vacancies for two Project Engineers for work at its Spun Iron Pipe plants. Applicants should be graduate engineers or hold equivalent qualifications and preferably be aged between 25 and 30. The posts are permanent and pensionable. The engineers selected will be engaged initially on work at Stanton but may ultimately be required to work overseas. Preference will be given to those prepared to travel abroad.—Write, in confidence, to the Staffing Officer. E8327 A

SENIOR DESIGN DRAUGHTSMEN, familiar with small mechanisms, etc., required by progressive and expanding Company situated approximately 20 minutes from Waterloo. The positions offered are permanent and provide excellent prospects for versatile men who seek interesting work in a new field.—BOX No. E169, "The Engineer." A

SENIOR PROJECT DRAUGHTSMAN required for Mechanical Handling Plants. Applicants must be able to lay out schemes. Experience in Estimating an advantage but not essential. Good prospects.—W. W. Brown & Partners, Ltd., 72, Newman Street, London, W.1. E2660 A

WANTED, FIRST-CLASS SENIOR DESIGN DRAUGHTSMAN for firm of General Engineers in Bristol. Good knowledge of general engineering, with particular reference to pressure vessels and stainless steel fabrication. This will be a well-paid position for the top-class man.—BOX No. E164, "The Engineer." A

WORK STUDY

A major industrial organisation requires a trained WORK STUDY ENGINEER with 3 to 5 years' experience in medium industry. The successful candidate must be able to work without detailed supervision and should also have some knowledge of mechanical handling. This is an interesting position and prospects are quite bright.—Please write, stating full details of age, experience and qualifications to BOX No. E8321, "The Engineer." A

HYDRAULIC DEVELOPMENT ENGINEER

required to take control of a Development Section specialising in Industrial Hydraulic Applications.

The post is a senior one which has been created within a Division of a Group of Companies of National Repute and it offers considerable scope to a man with ability, drive and imagination.

The commencing salary scale is £1200 to £1600 p.a., depending upon experience and qualifications. A Pension Scheme is in operation. Assistance will be given in housing and removal expenses to the North of England.—Apply BOX No. E8325, "The Engineer." A

MATERIALS HANDLING ENGINEER

Required for a medium-sized company manufacturing specialised equipment for the vehicle and motor-car industries. The Materials Handling Engineer will be responsible to the Production Engineer for materials handling and factory layout.

Essential qualifications :—
(a) Experience in the preparation of materials handling schemes, including palletisation and conveyorisation in current use in the light mass-production engineering industry.
(b) Sound knowledge of modern factory layout for batch and flow production in machine, assembly and plating shops.
(c) Knowledge of machine design, planning, work study and foundry practice would be an advantage.

Candidates should have professional qualifications in production or mechanical engineering.

Age group : 30 to 45. Four-figure salary and non-contributory pension scheme. Please send full details of career in confidence quoting reference LRM/PE.2, to CLAYTON DEWANDRE COMPANY LIMITED, Titanic Works, Lincoln. E8212 A

SITUATIONS VACANT

PROJECT ENGINEER

Applications are invited from suitably qualified persons for appointment as Project Engineer in an expanding Division of an old-established Company in Yorkshire.

The work is concerned with controlled atmosphere generators and gas drying equipment, and the project engineer would be responsible for the design, installation and subsequent testing of new plant, and the work would involve some time spent on site.

Candidates should have a technical qualification in chemical engineering or fuel technology, preferably to degree standard.

Superannuation scheme and other benefits.

Salary by arrangement.

Please send brief details in confidence, quoting Ref. GHD, to BOX No. E8310, "The Engineer." A

SITUATIONS VACANT

PRESSED STEEL COMPANY LIMITED

The Company is engaged in large-scale manufacture of Motor Car Bodies, Commercial, Domestic and Industrial Plant and Railway Rolling Stock, and employs some 20,000 in plants at Oxford, Reading, Swindon and Paisley. It invites applications for the following appointment :—

PLASTICS TECHNOLOGIST

Qualified Plastics Chemist to strengthen a research and development team working on the application of plastics to the Company's products. Degree in Chemistry and experience in the research and development department of a large industrial chemical company essential ; special knowledge of reinforced plastics, thermoplastics, polyesters, polystyrenes, epoxy resins and their applications desirable. Associate Membership of Institute of Plastics an advantage. Age range up to 35 years. Location Oxford.

This opening offers the opportunity to join an expanding organisation in research and development of new techniques of manufacture. Conditions of employment accord with best industrial practice. Applications, with full details of education, training, experience, and salaries earned, may be made to the Staff Officer at Cowley, Oxford. E8312 A

KELLOGG INTERNATIONAL CORPORATION

the leading contractors in petroleum refinery and chemical plant construction, invite applications for the following positions.

HEAT TRANSFER ENGINEER

Applicants should have University Degree in Chemical or Mechanical Engineering, plus 3 years' service in industry—or H.N.C. plus 5 years' experience in industry—should be experienced in process or power plant design and must be capable of carrying out all thermodynamic calculations necessary for the design of Heat Exchangers. The selected applicant will be responsible for analytical, thermal and mechanical design of Heat Exchangers and Furnaces ; preparation of data sheets and specifications for Exchangers ; Thermal calculations for Heat Exchangers ; preparation of Exchanger setting plans and drawings ; checking of these diagrams and drawings ; review of quotations and vendors' drawings for Heat Exchangers and Furnaces.

INSTRUMENT ENGINEERS

Candidates must have University Degree with 4 years' experience in Instrument Engineering or H.N.C. with 6 years' experience. Experience should preferably be in refinery process instrumentations. Operating experience would be an advantage. Duties of the successful applicants will cover the selection of instruments, the determination of their location, and applications in the process ; preparation of process control diagrams, instrument specifications and data sheets ; writing of requisitions and review of vendors' quotations ; instrument calculations, locating the physical position of instruments and the preparation of instrument board layouts.

Above average salaries, comprehensive personnel benefits include contributory pension scheme, excellent working conditions, luncheon vouchers, Social Club, etc.

Please write to the Personnel Manager,
KELLOGG INTERNATIONAL CORPORATION
KELLOGG HOUSE · 7-10, CHANDOS STREET · LONDON · W.1.
QUOTING REFERENCE 148/G
Telephone : MUSeum 4010 E8304 A

British Titan Products Co Ltd

have vacancies for

MECHANICAL ENGINEERS

at their Grimsby and Billingham Factories.

The Company is primarily concerned with the manufacture of Titanium Dioxide and is characterised by a tenfold expansion in post-war years. This continuing expansion offers plenty of scope for Engineers in the fields of Plant, Maintenance, Construction and Design. The current vacancies are for Maintenance and Construction work with opportunities later in the Design field.

Preference will be given to candidates with a University Degree in Mechanical Engineering, but those with an equivalent professional qualification will also be considered. Post-graduate apprenticeship is essential and the upper age limit for the appointments is 30.

Salaries and prospects are very attractive for men with the right qualifications. Annual bonus scheme and non-contributory endowment assurance and assistance for married men with house purchase and removal expenses.

Applications, in strictest confidence, to be addressed to the

Personnel Manager,
British Titan Products Company, Limited,
Billingham, Co. Durham, quoting reference S.4.

E160 A

Classified Advts. continued on page 76

SITUATIONS VACANT

DEPUTY PRODUCTION ENGINEER

Required for a medium-sized company manufacturing specialised equipment for the vehicle and motor-car industries.

The Deputy Production Engineer will be responsible to the Production Engineer for the supervision of engineering staff covering process planning, work measurement, tool design and manufacture.

Candidates, who should have professional qualifications in production and mechanical engineering, must have extensive experience of modern machine tools, process planning, jig and tool design and work study in the light mass-production engineering field.

Experience in the design of special purpose transfer machines would be an advantage.

Age group : 30–45. Four-figure salary and non-contributory pension scheme. Please send full details of career in confidence, quoting reference LRM/PE.1, to CLAYTON DEWANDRE COMPANY, LIMITED, Titanic Works, Lincoln.

E8211 A

SUB-CONTRACTING

CASTINGS.—We can save your porous castings, ferrous or non-ferrous, by an approved impregnation process ; sample castings treated ; A.I.D. approved. —Recupero, Ltd., 66, South Harrow Viaduct, Harrow, Middlesex ('Phone, Byron 1178). E109 MW

KELLERING AND CAM PROFILING capacity up to 8ft. by 6ft. or 6ft. diameter.—ARMYTAGE BROS. (KNOTTINGLEY), Ltd., The Foundry, Knottingley, Yorkshire (Telephone : Knottingley 2743/4). E116 MW

MOBILE LIFTING SERVICES.—Lump sum or Hire Rate Quoted for any Lifting Work by Lorry-Mounted or Crawler Cranes, any size, any area.—TARSLAG, LTD., Rotherham 3235. E167 MW

BUSINESS OPPORTUNITIES

REMPLOY SPONSORSHIP SCHEME.—Send for details which show an attractive proposition to manufacturers.—Write to the Managing Director, Remploy, Ltd., 25–28, Buckingham Gate, S.W.1, or telephone VICtoria 6621 (12 lines). E155 D

PATENTS

THE PROPRIETOR of British Patent No. 755082, entitled "SUBSURFACE WELL TOOLS," offers same for license or otherwise to ensure practical working in Great Britain.—Inquiries to Singer, Stern & Carlberg, 14, E. Jackson Boulevard, Chicago 4, Illinois, U.S.A. E8264 H

FOR HIRE

LATTICE STEEL ERECTION MASTS (light and heavy), 30ft. to 150ft. high, for immediate hire.—Bellman's, 21, Hobart House, Grosvenor Place, S.W.1. E103 K

MISCELLANEOUS

REQUIRED back numbers of "The Engineer" for July 5th, July 12th and November 1st, 1957. Reasonable prices and expenses paid. —Write in first instance to The Hunslet Engine Co., Ltd., 125, Jack Lane, Leeds, 10. E173 I

BUSINESSES and PREMISES

PRECISION ENGINEERING BUSINESS for Sale. Turnover £75,000 per annum. Directors retiring.—BOX No. E172, "The Engineer." L

MACHINERY Etc. WANTED

WANTED.—Crane on own chassis or lorry-mounted. All types up to 8 ton considered.—BOX No. E8156, "The Engineer." F

FOR SALE

HORIZONTAL BORING AND FACING MACHINE

Richards No. 2 HORIZONTAL BORING AND FACING MACHINE. Model PRT 2N. 3in. traversing spindle. Facing head to face up to 30in. dia. Screwcutting by change gears. Facing head to end stay 6ft. 6in. M.D. 400/3/50. H. BELL (MACHINE TOOLS) LTD., WALTER STREET, LEEDS, 4. Tel. 63–7398. E105 G

NISSEN TYPE HUTS for sale. Prompt despatch of 16ft., 24ft., and 30ft. wide huts ; also "Romney" Huts, 35ft. wide, and "Blister" Hangars, 86ft. 6in. and 91ft. wide. These buildings are in various lengths and comprise steel framework with galvanised corrugated steel sheeting.—Full details from Dept. 115, J. Thorn and Sons, Ltd., Brampton Road, Bexleyheath, Kent. (Tel.: Bexleyheath 305). E113 G

FOR SALE

TWW

RAILS FOR SALE

100 TONS NEW SLIGHTLY DEFECTIVE B.H. RAILS, 95 lb. yard, chiefly 60ft.
100 TONS SLIGHTLY DEFECTIVE F.B. RAILS, 109 lb. yard, chiefly 60ft. lengths.
100 TONS NEW SLIGHTLY DEFECTIVE F.B. RAILS, 91 lb. yard, chiefly 42ft.
100 TONS GOOD SECOND-HAND B.H. RAILS, 80/85 lb. yard, B.S. Section, chiefly 60ft.
100 TONS SECOND-HAND BULL HEAD RAILS, 90/95 lb. yard, chiefly 44ft. 6in. lengths.
50 TONS NEW SLIGHTLY DEFECTIVE F.B. RAILS, 93·34 lb. yard, chiefly 41ft.
100 TONS NEW PERFECT F.B. RAILS, 75 lb. yard, R.B.S., chiefly 40ft. lengths.
1500 TONS UNUSED BUT STOCK RUSTY F.B. RAILS, 75 lb. yard R.B.S., chiefly 36ft.
50 TONS NEW SLIGHTLY DEFECTIVE F.B. RAILS, 80 lb. yard, Revised B.S. Section, lengths chiefly 40ft.
250 TONS SECOND-HAND F.B. RAILS, about 60 lb. yard, 24ft., 27ft., 30ft. and 45ft.
10 TONS SECOND-HAND COACH SCREWS, 6¼in. by 1¼in., Standard Railway Pattern.
50 TONS MILD STEEL FLAT, 5in. by ¼in., New but Stock Rusty, 15ft. to 26ft. chiefly.
WARD'S ALSO HAVE LARGE STOCKS OF ALL CLASSES OF OTHER RAILWAY MATERIALS

THOS. W. WARD LTD.

ALBION WORKS - - - - SHEFFIELD
'Phone : 26311. 'Grams : "Forward."
E215 G

Edwards

RUSHWORTH Power Operated, Double Geared, Open Ended Guillotine Shearing Machine, Overcrank type, arranged motor drive for 380/440/3/50, capacity mild steel 4ft. by ¼in., gap in open ends 6¼in., weight approximately 50 cwt.
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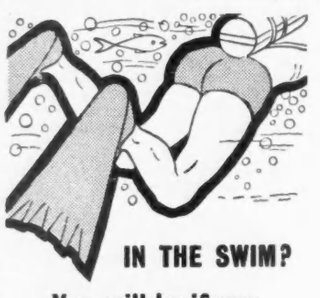

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January 15	**Miscellaneous stores,** including :—	Returned Stores Group, **Reed Hall, Colchester, Essex.**	**FENN, WRIGHT & CO.** (Dept. L), 146, High Street, Colchester, Essex. (Tel.: 3171.)
	Tools, Reyrolle welding plants, 600-gallon fuel tanks, platform weighing machines, electric cable, fire fighting equipment, cooking equipment, furniture, carpets, blankets, khaki drill and other clothing, canvas tents and covers, scrap metal ; etc.		
February 2	**Miscellaneous stores.**	M.O.A. Storage Depot, **Ruddington, Notts.**	**WALKER, WALTON & HANSON** (Dept. L), Byard Lane, Bridlesmith Gate, Nottingham. (Tel.: 54272.)
February 10	**Miscellaneous stores.**	Technical Stores Depot, **Old Dalby, Leics.**	**SHOULER & SON** (Dept. L), 1, Norman Street, Melton Mowbray, Leics. (Tel.: 3081.)

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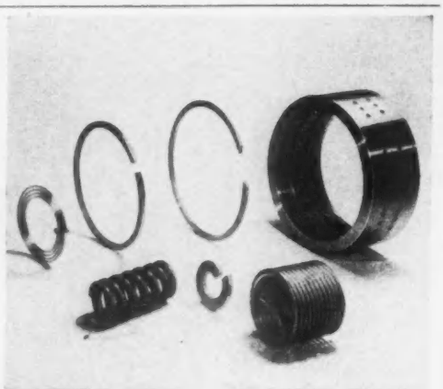

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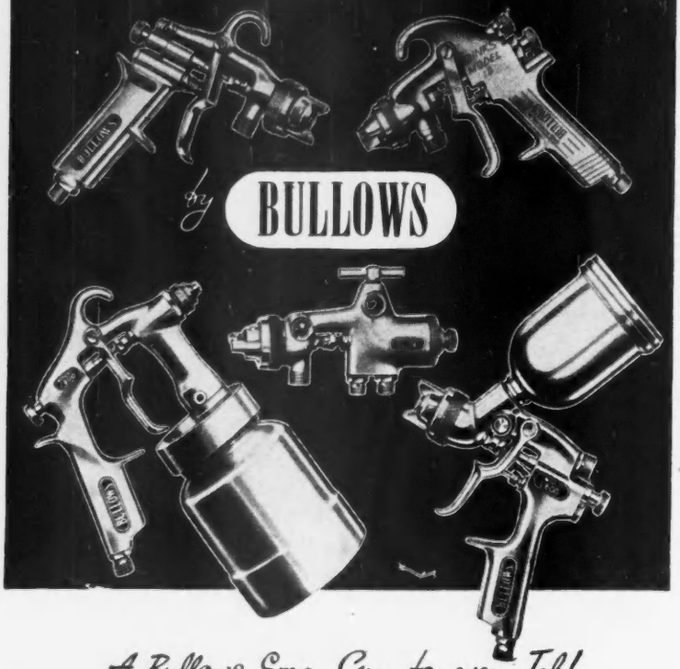

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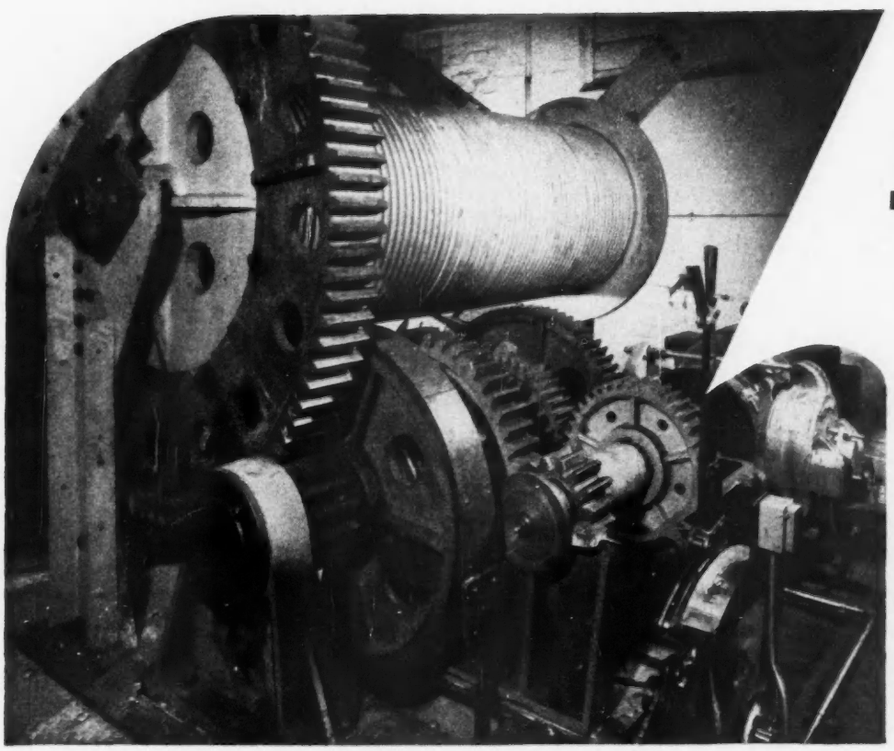

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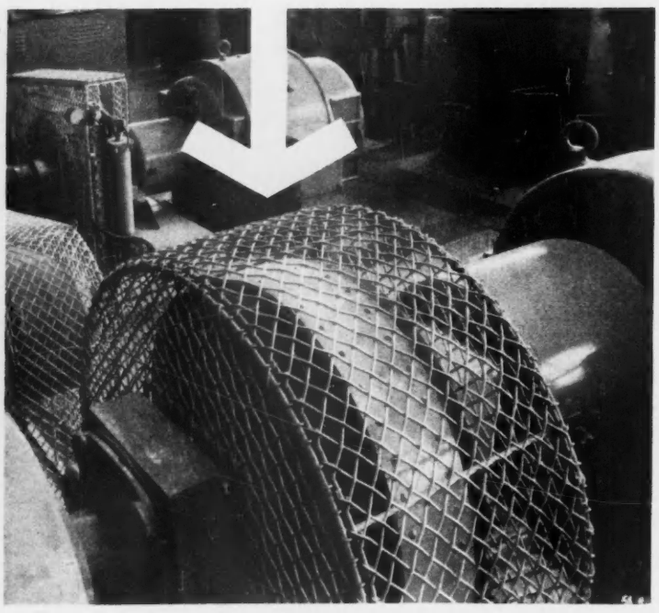

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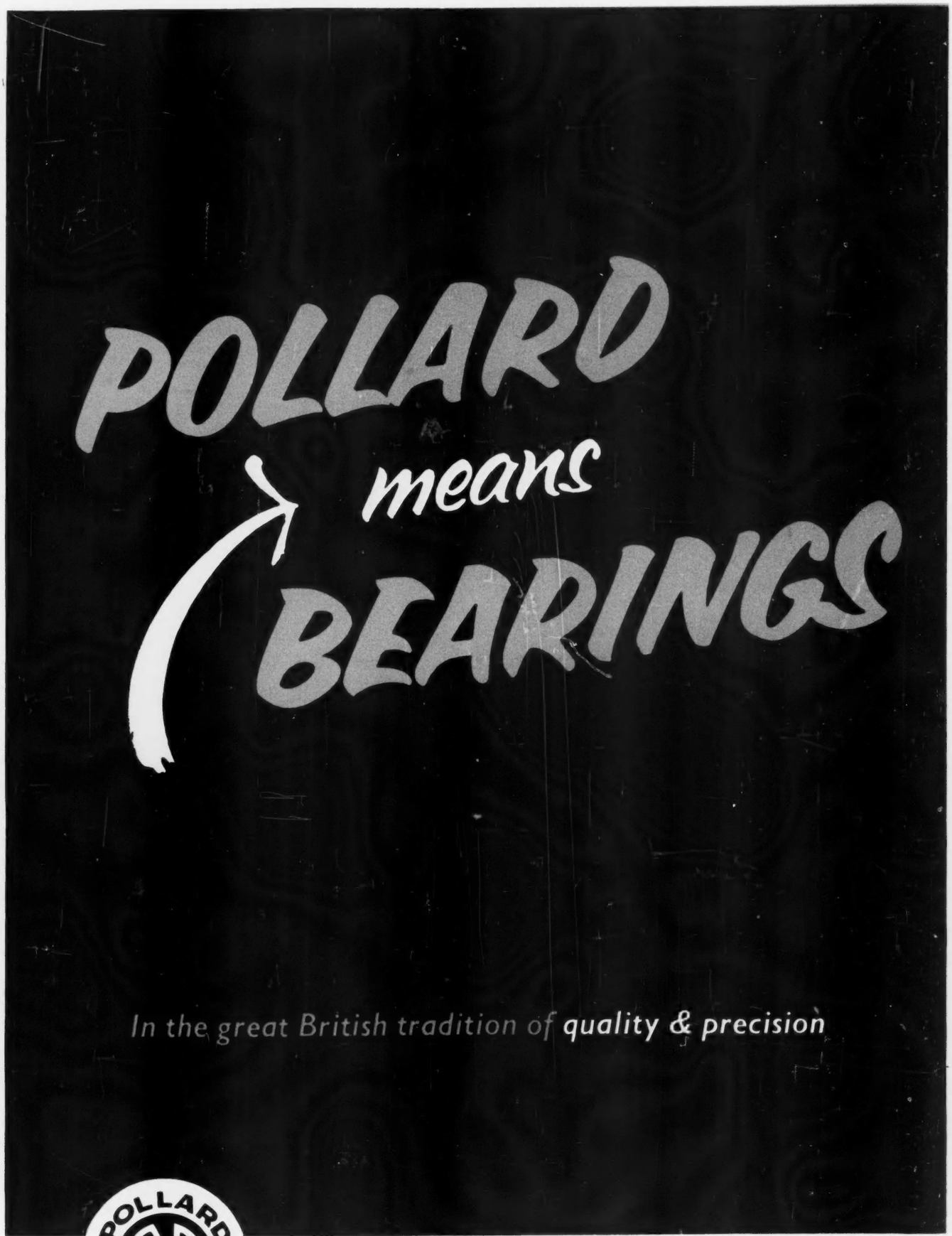

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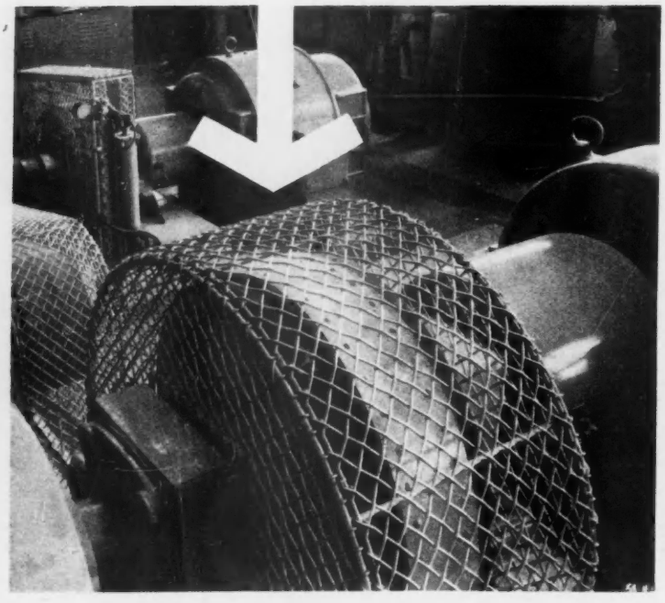

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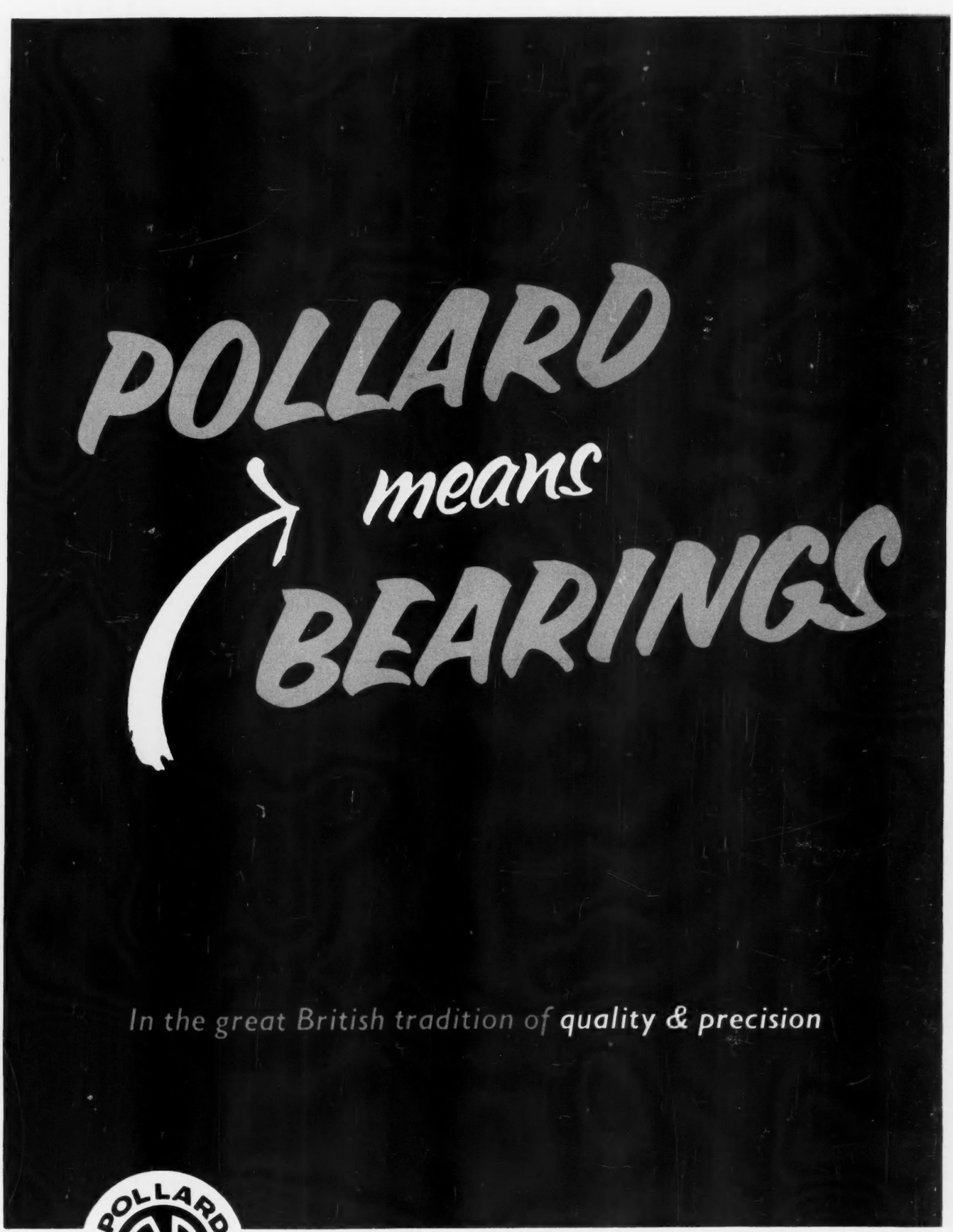

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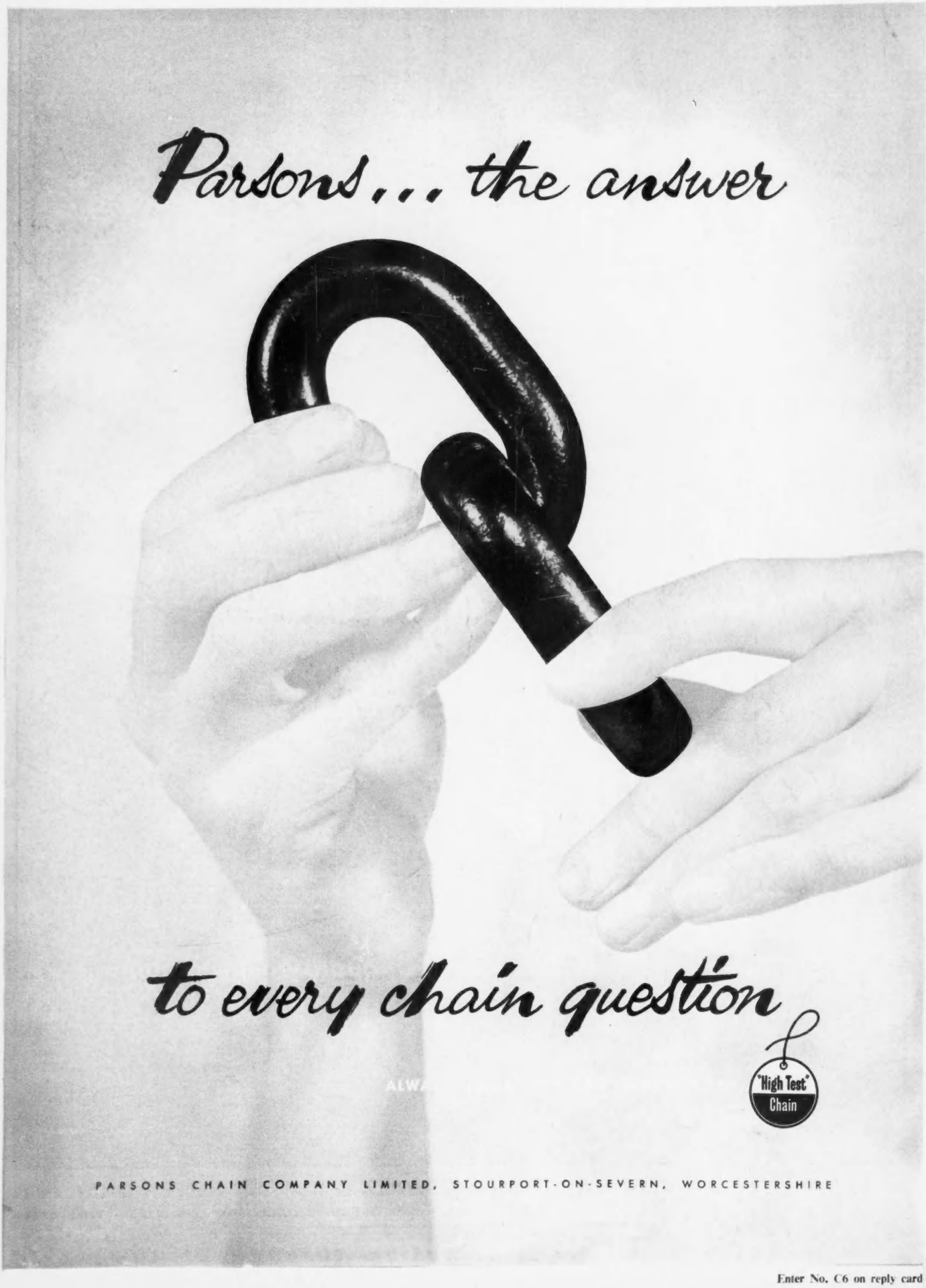

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